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AFBITS Experimental Equipment Evaluations

W. T. Grinnell

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DEPUTY FOR PLANNING, TECHNOLOGY AND REQUIREMENTS

ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Hanscom Air Force Base, Bedford, Mass.



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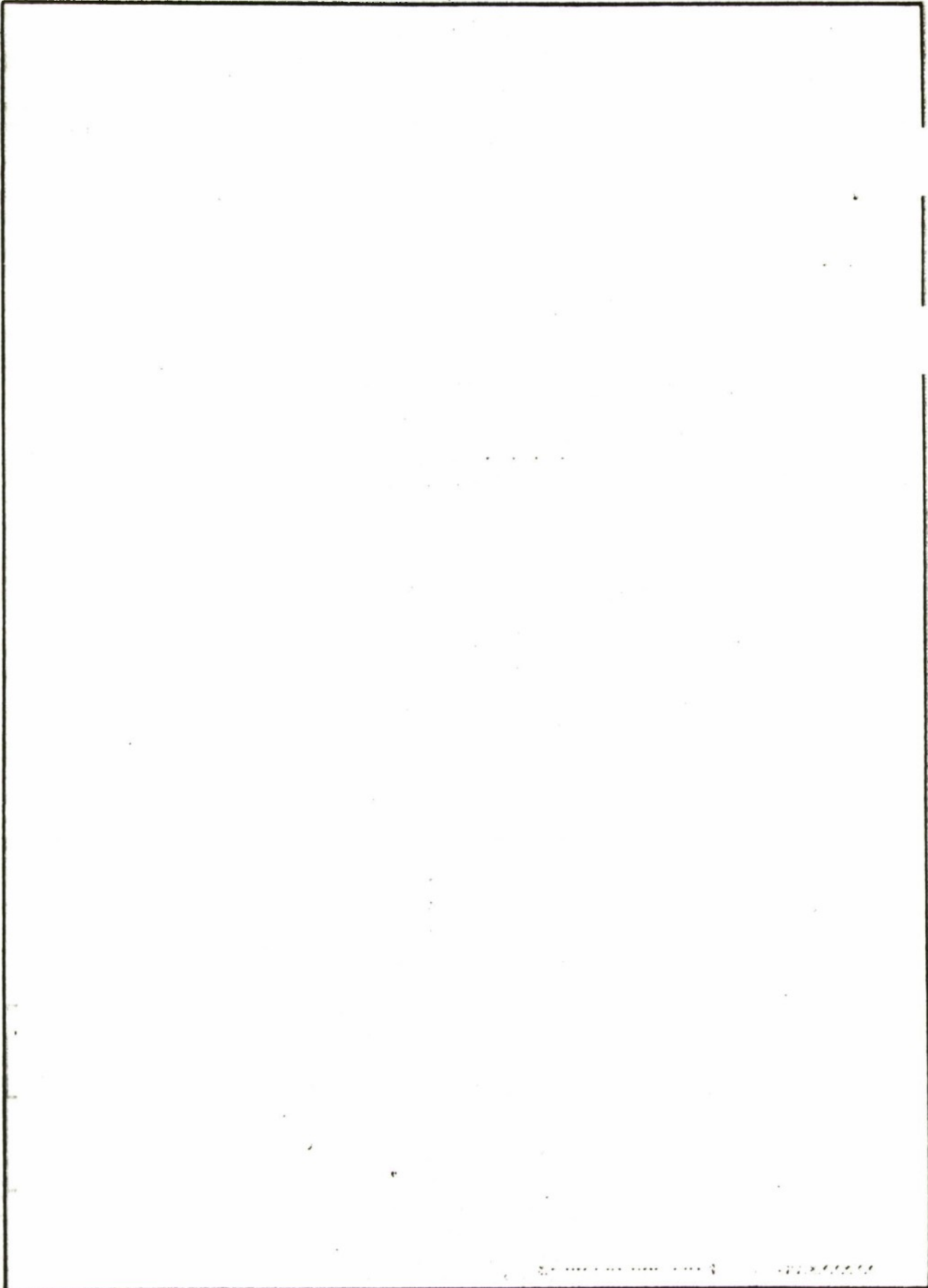


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SECTION I

INTRODUCTION

The Air Force Base Information Transfer System (AFBITS) is an integrated multimode communications system designed to satisfy existing and future needs for information transfer on Air Force bases. Through use of broadband transmission media such as coaxial cable an integrated multimode information transfer system can be implemented which provides audio, digital data, message and video communications simultaneously in a variety of connectivity patterns. These various connectivities include: telephone point-to-point; the many-to-one connectivities required for remote access to computers; the one-to-many or broadcast mode; and the many-to-many or conferencing mode. With these capabilities, a variety of simultaneous user services such as text processing, resource sharing, remote data input and access, with simultaneous communications to computer and microfiche data bases, can be provided.

The principal electrical communications facility on Air Force bases today is the dial telephone system which provides point-to-point voice services and some limited digital data transmission capability on either switched or dedicated line bases. Limited video services are provided by CCTV facilities on some bases and commercial programs are available from over-the-air broadcast and the community antenna television (CATV) industry. The primary means of information transfer on Air Force bases however is through physical transport of hard copy in the form of letters, memoranda, reports or cards and magnetic tapes.

The production and handling of the large amounts of paper necessary to satisfy information transfer requirements on Air Force Bases requires substantial numbers of people to provide this service in the Communications, Administration and Data Automation functions.

Additionally all mission and function users of the information transfer system spend an appreciable portion of their time in the handling of paper in order to accomplish their primary job function. The implementation of a broadband integrated multimode telecommunications system such as the AFBITS should permit a substantial portion of this information transfer to be accomplished by means of automated electrical soft copy with a consequent reduction in the numbers of communications "provider" personnel and time savings in mission user groups. Such a system is intended not merely to automate the paper work process, but rather to replace it to the greatest extent possible with soft copy generation, composition, storage and transmission of information. Hard copy would therefore be employed only when absolutely essential.

In order to evaluate the technical and operational interface problems in developing a broadband integrated multimode information transfer system like AFBITS an experimental evaluation facility consisting of representative types of data and video terminals and devices interconnected by broadband cable and switches has been configured. With this setup, a variety of video display and typewriter oriented terminals have been interfaced and interconnected through a broadband switch which is remotely controlled by manually activated keypads. Various types of video devices such as surveillance cameras, an automatic microfiche retrieval unit, framegrabbers, video tape recorders and copiers have been interconnected and evaluated. An interface has also been effected with a coaxial cable facility. The results of this evaluation are described in succeeding sections of this report.

SECTION II

AFBITS EXPERIMENTAL CONFIGURATION

The AFBITS experimental configuration was the result of a plan for the evaluation of equipments and transmission plant of the type required for configuration of a broadband multi-mode communications system. The facility layout (Figures 1, 2, and 3) consisted of two rooms; the head-end, and the subscriber terminal room.

The primary function of the head-end was system connectivity control. The keypad access and status devices which were used for establishment of initial connectivity were terminated in a Time Division Multiplex (TDM) supervisory controller, and all terminal and common equipment coaxial input/output cables were terminated in a broadband matrix switch. The TDM supervisory controller is a device that receives and interfaces connectivity request information from a subscriber's work station keypad to a PDP-11 minicomputer network control simulator. The simulator assembled digital information, addressed the broadband switch, and sequenced the requested connectivity code into the broadband switch controller.

The broadband switch, in conjunction with the PDP-11 network control simulator, was similar in operation to an automated patch panel in as much as it received digital commands and made switch closures. The basic switch matrix was a 5 x 10 array of coaxial switches to which, through a manually operated coax patch panel, a variety of input/output information carrying user terminal, external trunk, common equipment, or test equipment coaxial cables were assigned. A subscriber access directory (telephone book), which was required as a guide for dial-up, reflected the equipment hard-wired connectivities to the broadband switch matrices.

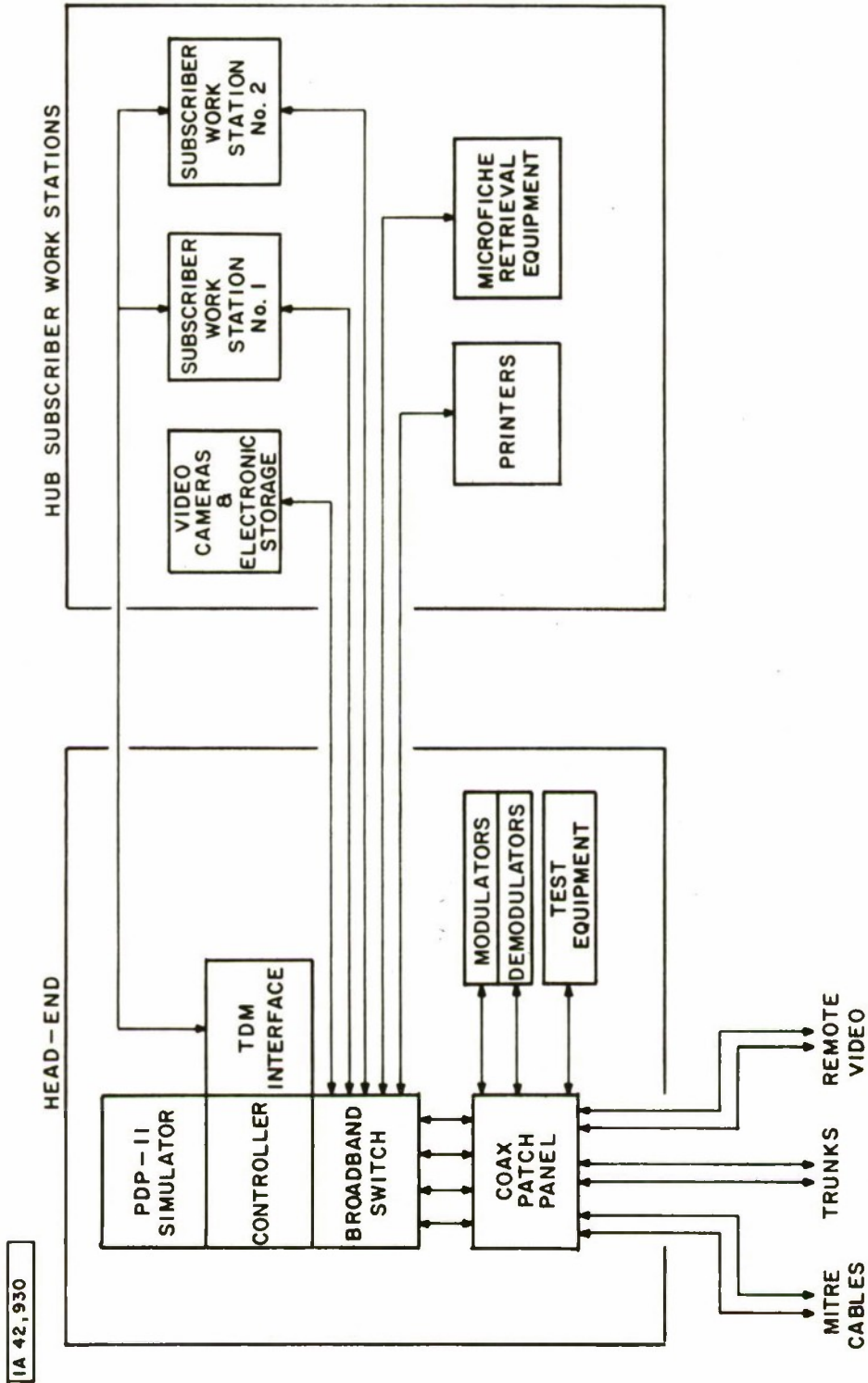
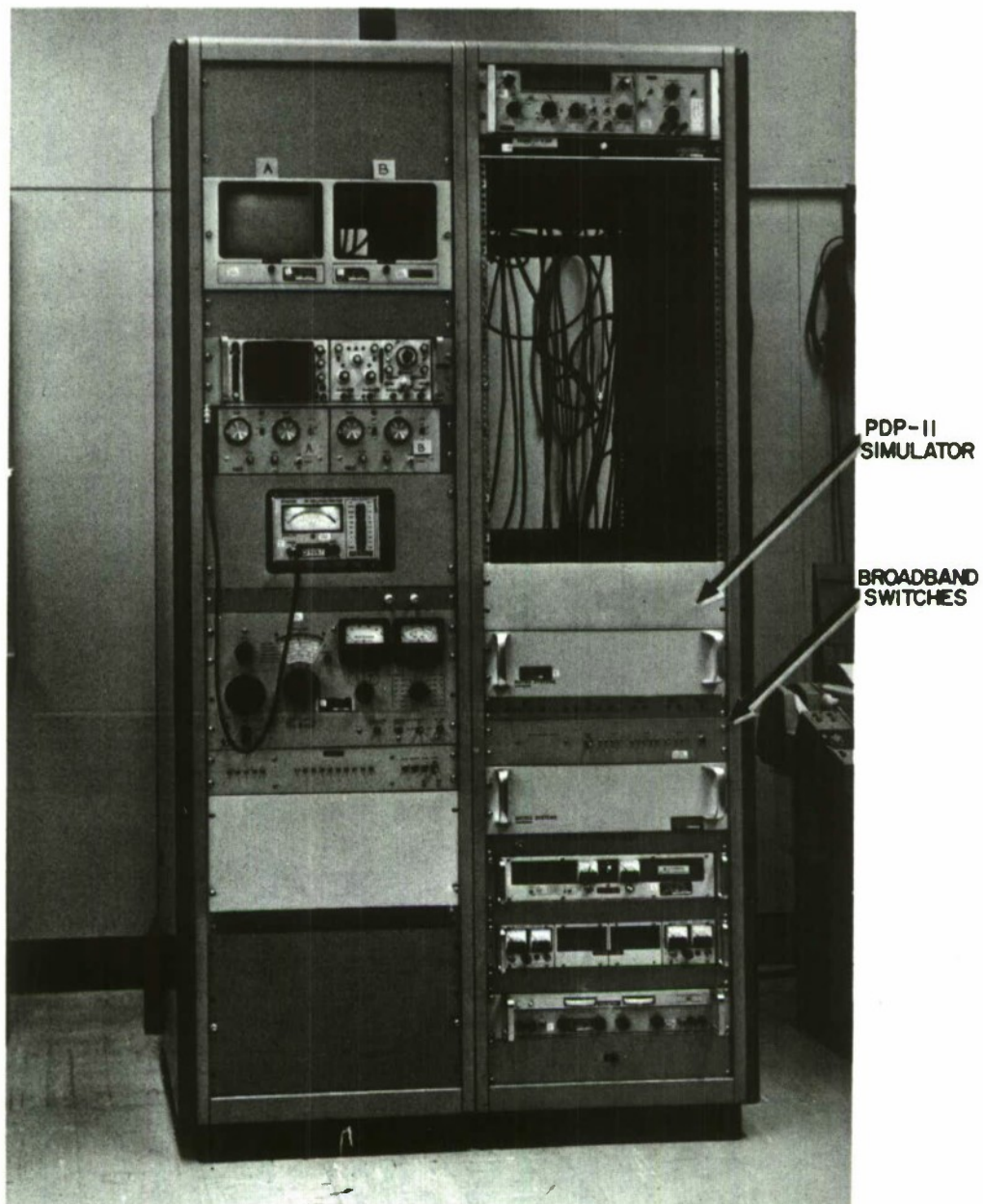


Figure 1 AFBITS EXPERIMENTAL CONFIGURATION



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Figure 2 HEADEND CONNECTIVITY EQUIPMENT



Figure 3 SUBSCRIBER TERMINAL ROOM

Because of the close proximity of the two rooms, the broadband switch, which would normally be located within a switching hub, was physically located within the head-end room. The user terminal room station equipment, consisted of an access entry keypad, data entry keyboard, and visual display monitor from which a variety of equipment interconnectivities could be implemented and studied. Common user equipment and keypad connectivity devices which would typically be installed at subscriber work stations were also located in this area. The major equipment and/or equipment configurations within the area were: two separate work station areas, high quality printers, microfiche storage and retrieval, and video generating equipment and storage devices.

High quality page printers for use in conjunction with soft-copy text preparation operations were also included as part of the evaluation. The printers produce high quality impressions suitable for use in external correspondence.

Microfiche storage and retrieval units which would normally reside in a base library or other data source location, were installed locally within the subscriber terminal area for purposes of demonstration, and for ease of evaluation.

Video generating, storage, and retrieval equipments, video cameras for monitoring and still picture broadcasting, surveillance video cameras, video cassette tape recorders, and video frame storage devices, all of which are part of a common set of user equipments, were located within the work area.

The first phase of laboratory work was centered around the evaluation of the equipment interfaces. Due to the variety of equipment input/output plug configurations, signal levels, handshake requirements, etc., a set of standards for equipment input/output ports had to be adopted. The principal standards used were

the USA Standards for Information Interchange, the Electronic Industries Association Standards for Data Terminal Interfaces, and the Electronic Industries Association Video Standards as listed in Section VIII of this paper.

After all equipments were interfaced, their data input/output channels were connected via coaxial cable to the broadband matrix switch through which various subscriber work station operational configurations were investigated.

SECTION III

TRANSMISSION PLANT

The development of an integrated communications system to handle simultaneous audio, data, and video traffic requires the utilization of a broadband integrated transmission plant such as multiple conductor cables, coaxial cable, radio transmission links or a combination of these. The most viable approach however appears to be the use of a coaxial cable transmission plant. With coaxial cable, the transmission and receiving traffic channels can be mixed into one upstream or downstream wideband, frequency division multiplexed transmission.

Such a system would consist of trunk lines used primarily for transmission of signals between the head-end and distribution areas, and feeder lines used for transmission of signals between the trunk system and the subscribers or hubs within a distribution area. Figure 4 illustrates a typical transmission plant. Additionally, tap units and service drops are required. A tap unit is a device that serves to connect the feeder cable to a service drop. In typical installations a directional coupler is used to provide minimum insertion loss to the feeder cable and a specific loss and isolation to the service drop. The service drop is also a coaxial cable that serves as the connection between the feeder cable and subscriber work stations.

CABLE IMPEDANCE

In order to maximize transmission efficiency and minimize distortion the transmission plant and system equipments must be impedance matched. The two values of impedance that are commonly associated with TV equipment - 75 ohms and 300 ohms - were derived

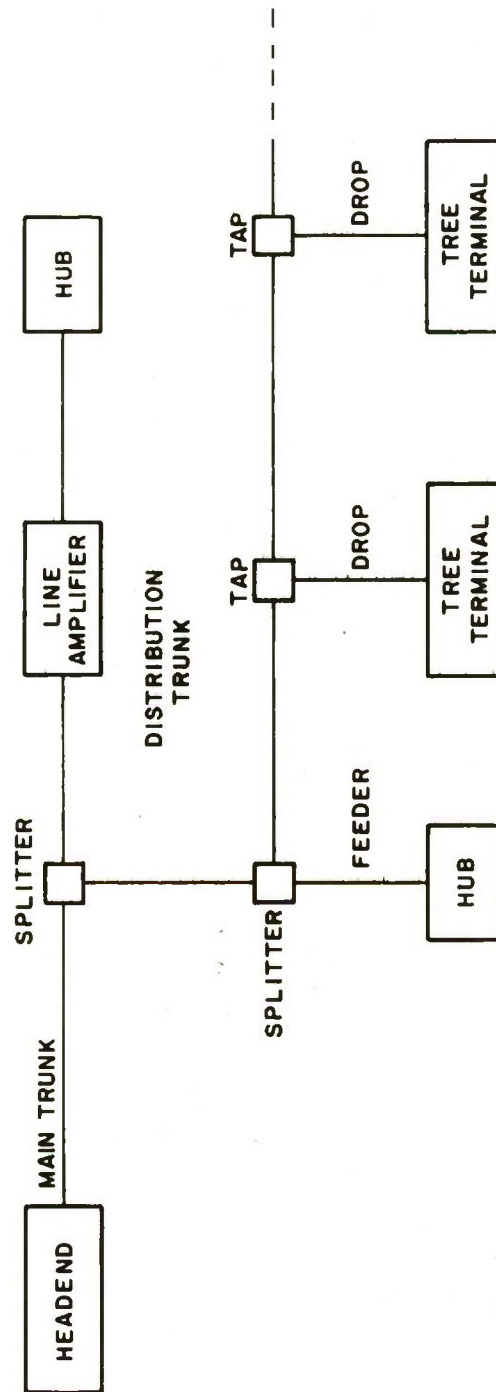


Figure 4 TRANSMISSION PLANT SCHEMATIC

from antenna and transmission line considerations for television receivers. The antenna/transmission line combination for television receivers must be efficiently designed not only to be a practical hardware device (for handling and ease of installation) but also to provide sufficient signal voltage intensities over a wide range of frequencies. Additionally, there are situations where the antenna is installed and operated at extended heights which require an operation that is independent of ground. A suitable antenna for the application is the half-wave Hertz which consists of two quarter-wave elements mounted on the same axis and insulated from each other. This type of antenna, commonly called a dipole, is efficient and easy to construct for operation at the Very High Frequency (VHF) associated with the TV band.

At any point on the antenna there is a definite value of current due to the RF voltage present and, at a given point, the impedance is equal to E/I . The current and voltage distribution along the half-wave dipole is such that the voltage is maximum at the element extremes while the current is maximum at the center tap points. At these points the antenna has a characteristic impedance of 72 ohms.

Another popular antenna is the folded dipole which is constructed of two half-wave lengths of wire joined at the ends with one wire open at the center where it connects to the transmission cable (similar in shape to the letter C turned on its side). The characteristic impedance of the folded dipole is approximately 288 ohms.

For the antenna to be effectively utilized it must be matched to a transmission line so that the antenna signal is delivered to a monitor with minimum loss. Early TV lead-in wire was economically produced as a two-wire parallel conductor transmission line that was constructed in the form of a plastic ribbon. Two line transmission lines, in general, have characteristic impedance that ranges from 200 to 800 ohms. From practical considerations the matching of

a half-wave folded dipole antenna to its associated monitor can be achieved using 300 ohm ribbon transmission line; however, this combination has several undesirable characteristics. The line is unshielded and subject to extraneous signal pickup especially when run close to power lines. In addition extra signal loss is encountered when the line is run close to metal structures such as drain pipes and metal siding. Another disadvantage is that signal strength is dependent on weather conditions which cause considerable variations dependent upon the humidity.

The use of coaxial cable circumvented many of the undesirable characteristics of ribbon cable; however, coaxial cable generally has a characteristic impedance of less than 100 ohms. A practical and efficient antenna/coax combination is the mating of a 75 ohm half-wave dipole to a 75 ohm coaxial cable.

TRANSMISSION LOSSES

Some of the principal losses that can occur in a transmission system are cable attenuation, feed-thru, termination, splitter, isolation, and temperature losses.

The cable attenuation loss is a function of frequency and represents a reduction of signal level as it propagates through the cable. Basically, the electrical properties of a coaxial cable are determined by the inductance and capacitance per unit length of cable. Of importance at low frequencies are the conductor resistance losses which are proportional to the square root of the frequency, power factor, and at high frequencies the shunt conductance which is determined by the dielectric loss and is proportional to the product of frequency, power factor, and dielectric constant. Typical coaxial cable attenuation curves are shown in Figure 5.

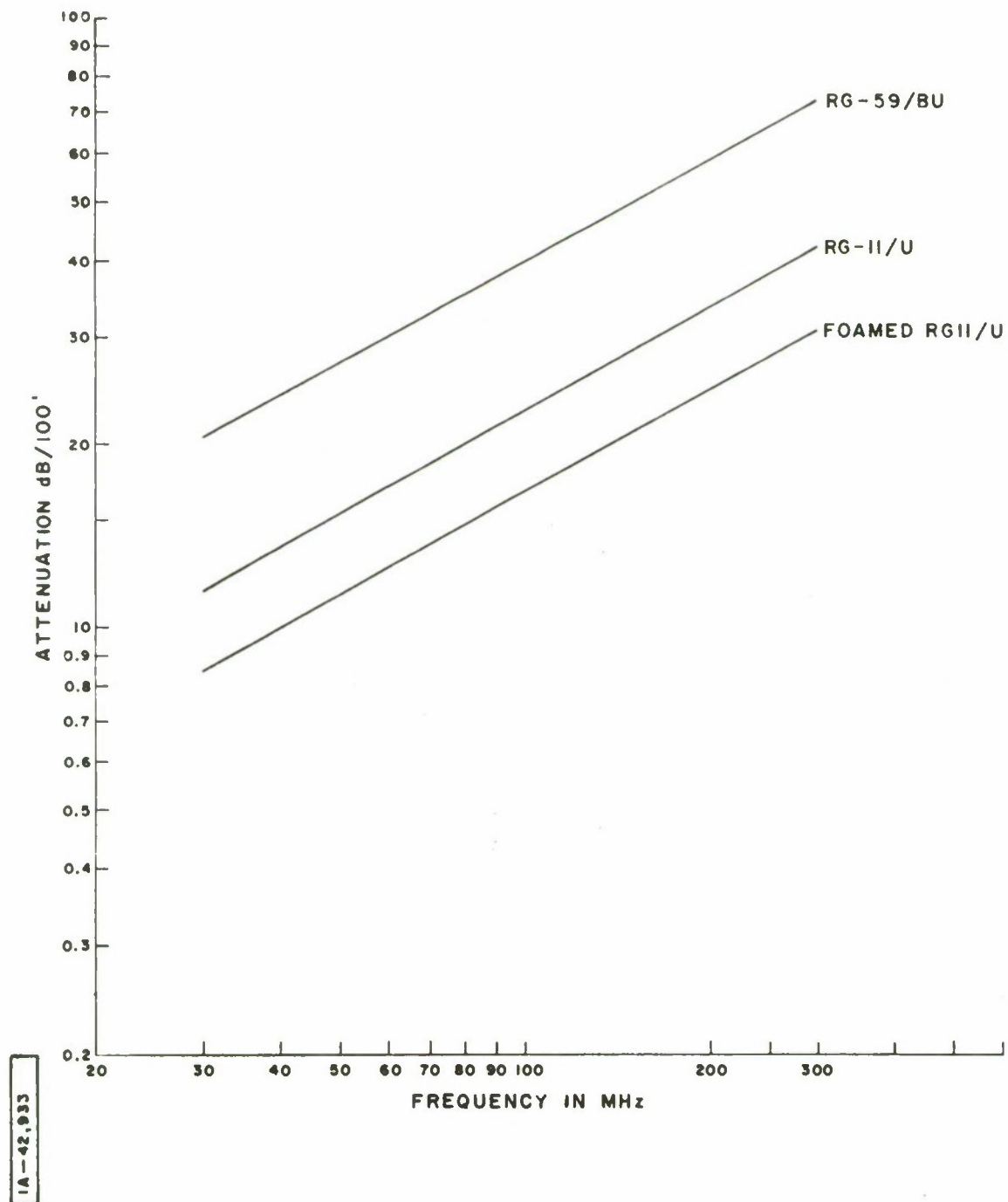


Figure 5 TYPICAL COAXIAL CABLE ATTENUATION CURVES

Feed-thru loss is a small loss of signal from the trunk line caused by drawing off a portion of the signal at each tap-off point. Although the loss is small, it must be accounted for in the system design. In general, feed-thru loss is in the order of 1 db or less per tap at 300 MHz.

Every trunk must be terminated in its characteristic impedance to prevent mismatches and unwanted signal reflections. The usual commercial practice is to terminate a trunk at the last tap on the line; normally a 3 db loss is taken at terminations.

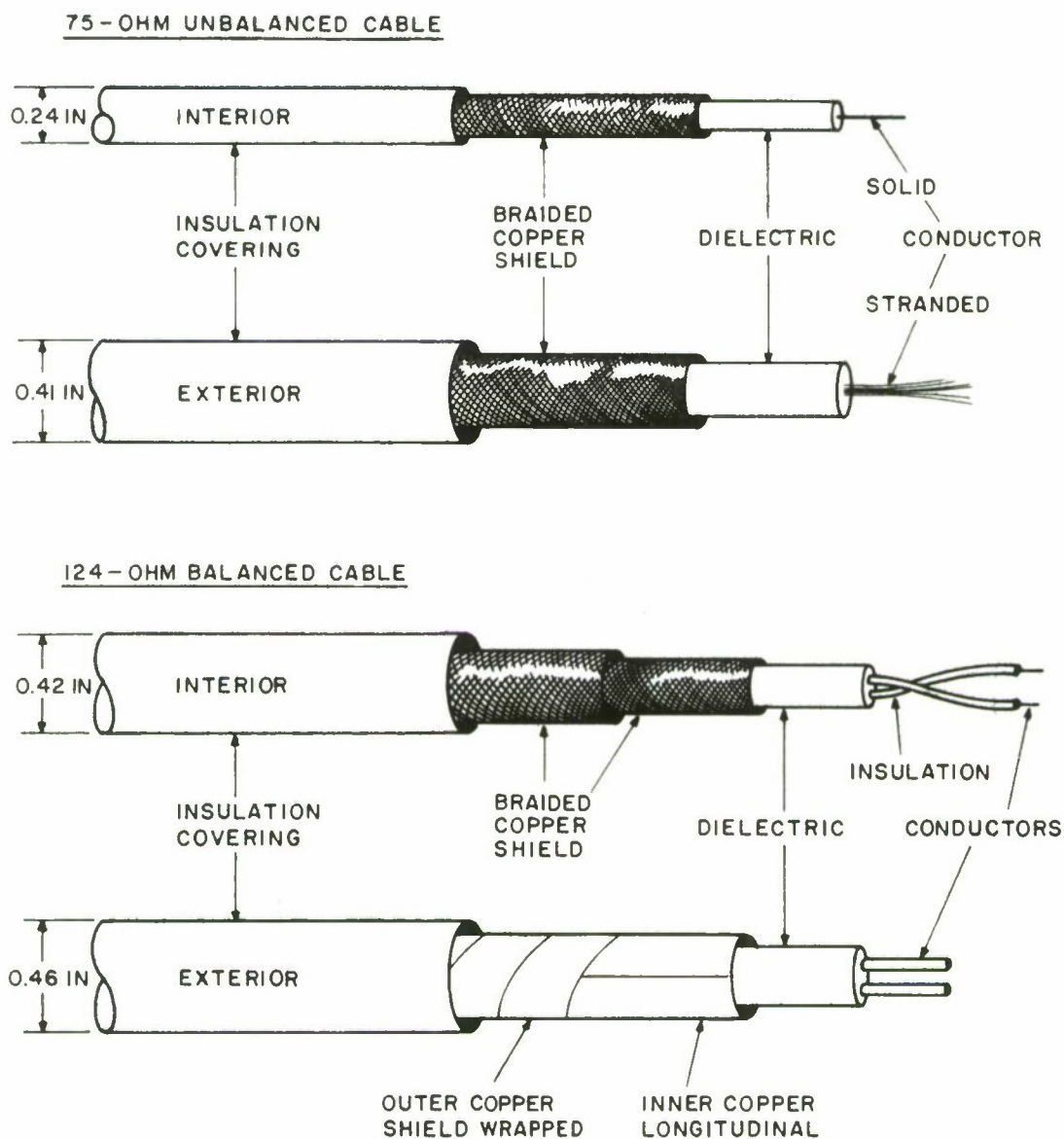
The physical layout of some bases may necessitate the splitting of a trunk line into two or more additional trunks. When a splitter is inserted the loss caused by dividing the signal must be considered. The insertion of a splitter will cause an average loss of 3.5 db at 300 MHz.

Signals from a feeder cable must be tapped and run to a subscriber's work station. To accomplish this a line tap is required. The tap should incorporate a degree of isolation sufficient to prevent interaction between subscribers on the same feeder. Line tap-offs are available with isolation ranging up to 20 db. The insertion loss to the signal from such a tap is in the order of 1 db or less at 300 MHz.

Considerations of temperature loss are given in the section discussing exterior coaxial cable.

CABLES

Four basic types of coaxial cable were considered for use in the AFBITS demonstration laboratory transmission plant. These included 75 ohm interior and exterior coaxial cable, and 124 ohm balanced interior and exterior coaxial cable. Typical physical configurations for these four types of cable are shown in Figure 6.



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Figure 6 TYPICAL COAXIAL CABLE CONSTRUCTION

Balanced Cable

Balanced coaxial cable consists of two isolated conductors embedded in a dielectric which is covered by two layers of copper shield and encased within an insulating jacket. The outstanding advantage of a balanced cable is that of hum reduction. In an unbalanced single coaxial cable, the cable shield is a part of the signal path and hum pickup can occur when a voltage potential exists between the cable shield and equipment chassis as frequently occurs on long cable runs. A condition resulting from a difference in AC voltage potential between the shield grounds at each end of the cable will cause an alternating current to flow through the cable shield. Because the shield is part of the signal path, an interference current, in the form of hum, will become mixed with the signal. As a result of this extraneous current, baseband video information from the cable, when viewed on a TV display, will contain alternating light and dark areas (hum bars).

Similarly when an unbalanced coaxial cable is located in the proximity of radiating equipment such as power line transformers, a situation could result in additional hum being induced into the cable.

One means of combating hum, therefore, is to eliminate the shield as a signal conductor and provide separate signal paths within the cable. To avoid the need for twin coaxial cables, a dual coaxial cable within a common jacket was developed by industry. This cable, with its two isolated signal carrying conductors, is connected at each termination in such a manner as to simulate the action of a center-tapped transformer. The signal information is applied in push-pull across the two signal carrying conductors and any ground currents are carried by the shield. Any induced AC hum or noise pickup is applied equally into each signal carrying conductor and appears in-phase at the termination of the run. At the termination point, the in-phase extraneous signals are cancelled.

Balanced cable has a characteristic impedance of 124 ohms and transmission losses slightly less than those of unbalanced cable. However, the cable cost is greater. Also the interfaces from unbalanced to balanced cable, and the line amplification equipment are more expensive to purchase and install because of the increased complexity of the associated electronics.

Balanced coaxial cables are most suitable for long trunk runs and in areas of high electrical interference. Telephone companies have been using balanced cable for many years in video distribution networks and have developed many special cables, some of which include multiple video pairs as well as audio and control wiring in the same cable sheath.

Unbalanced Cable

Unbalanced coaxial cable, as shown in Figure 6, is a single conductor shielded cable that is manufactured in several impedances usually ranging between 20 to 100 ohms. The cable is available in a variety of configurations with the primary difference being in the shielding and dielectric used. Typically, shielding may be standard braid, double braid, or solid aluminum; the dielectric may be foam, solid plastic, or air.

In the experimental facility, and in most anticipated hub configurations, many of the coaxial cable runs will not exceed 2000 feet and will be contained in an enclosed environment normally within a building. Therefore, with judicious planning, the cable installation can be routed to avoid high noise areas. Additionally, due to the short runs and commonality of the AC power supply, ground currents and the resulting induced hum should be at a minimum. For these reasons and considerations of economy, an unbalanced distribution system was chosen.

The choice of an unbalanced distribution system allows utilization of a wide variety of off-the-shelf CATV commercial cable equipment with a resultant additional economy in cost, installation, and maintenance.

Interior Cable

An investigation of cable installation procedures was made in order to become aware of any potential problems that might exist.

Interior cable, in general, is smaller in diameter than outdoor cable and is more flexible because it uses a braided shield. The flexibility is a desirable feature as the cable, in many instances, must conform to various twists and turns as it is run around corners and other obstacles. However, since the outside diameter of the cable is small, the inner conductor of the cable must be proportionally smaller in diameter in order to maintain the correct electrical impedance. Should any decrease in the diameter of the cable occur, there will be a corresponding increase in the signal attenuation of the cable, especially at the higher frequencies. Because of its small size, the cable is susceptible to damage by sharp bending, kinking, and indentations that occur when the cable is stepped on. The cable is best run either on a surface or some other supporting element, as hanging or stringing long runs of cable could result in ultimate stretching with a resultant shrinkage of diameter.

Exterior Cable

Exterior coaxial cable is generally one-half inch or larger in diameter and is not exceptionally flexible. However, the electrical qualities are considerably better than those of interior cable. The larger diameter conductors result in lesser signal losses and the rigid construction permits it to take greater abuse. For

example, an RG-11 exterior coaxial cable will not normally be damaged by a person stepping on it. The cable may be suspended on poles, run on top of the ground, or buried.

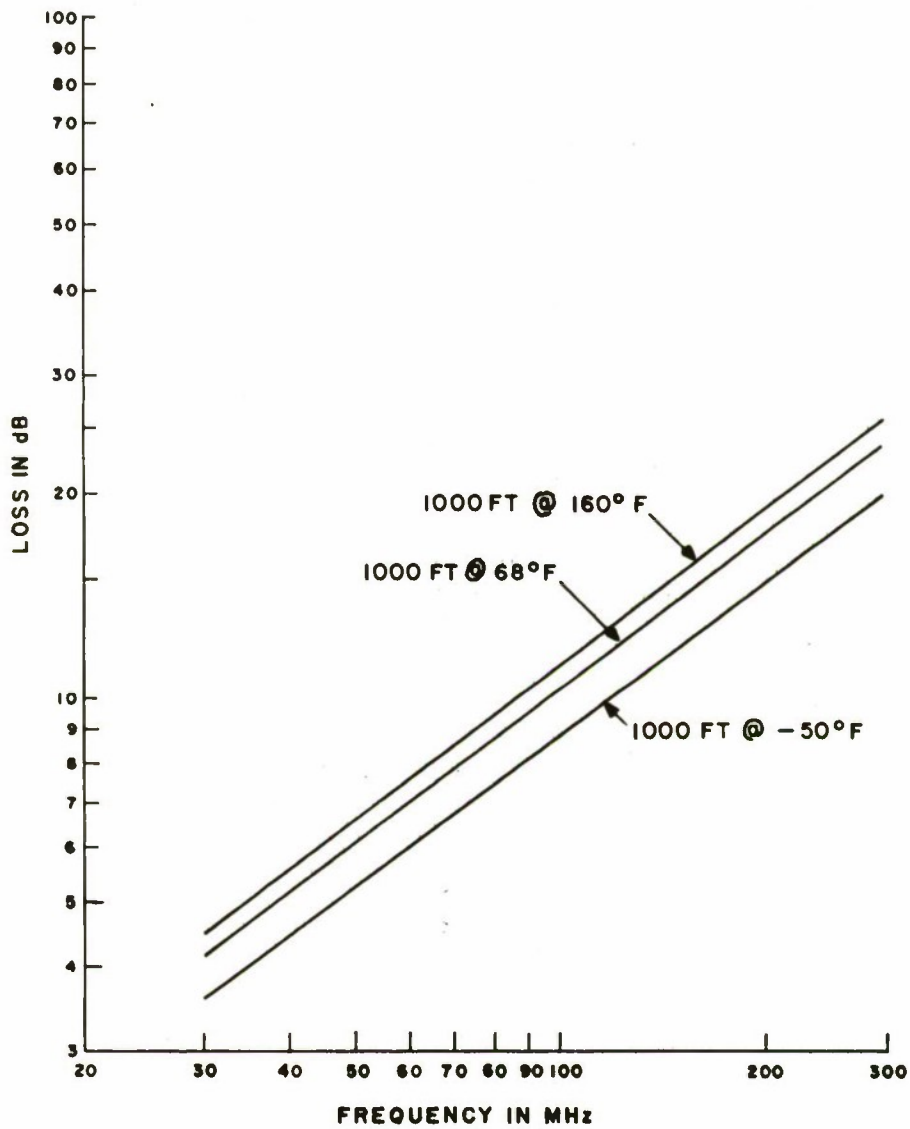
The environment to which the cable is subjected is very important since variations in the attenuation characteristic of the cable occur as the ambient temperature surrounding the cable changes. Typical exterior coaxial cable experiences a change of attenuation in decibels of approximately 0.1 percent per 1000 feet with each degree of Fahrenheit change in the ambient temperature surrounding the cable. Due to the physical expansion and contraction of the length and diameter of the cable with variations in temperature, the cable impedance varies in a direct proportion to temperature. Figure 7 shows a typical temperature curve.

For long cable runs, in the order of 1500 feet or greater, it may be advantageous to install buried cable. The temperature variation for underground cable would be much less than cable installed in open air. This would be true of the yearly variation as well as that from day to night, or between sunny and shady areas.

INSTALLATION COSTS

In addition to investigating the electrical characteristics of the transmission plant, consideration was given to installation costs.

Table I lists typical 75-ohm coaxial cables and their costs.



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Figure 7 TYPICAL TEMPERATURE CHARACTERISTICS OF COAXIAL CABLE

| CABLE TYPE | IMPEDANCE | USE | CABLE COST PER 1000 FEET |
|--------------|--------------------|----------------------------|-----------------------------|
| RG-59 U | 75 ohm | Interior | \$ 52 |
| RG-59 B/U | 75 ohm Low Loss | | \$ 63 |
| RG-11 U | 75 ohm | Interior or Exterior | \$122 |
| RG-11 U Foam | 75 ohm | | \$155 |
| RG-13 A/U | 75 ohm | Direct Burial | \$228 |

Table 1. Typical Coaxial Cable Costs

Interior Installation

Interior cable installation has many variables associated with it; old or new construction, conduit or other duct installation, average or rugged cable, and work force installation experience, to mention a few. Coaxial cable is not generally installed as the transmission plant in commercial buildings and installation data are limited. Based on data from commercial installers, the average installation price varied between \$1.00 and \$1.50 per foot of cable which included the cost of the cable.

Exterior Installation

There is a large amount of data available regarding external cable installation because of the many CATV systems in operation. Typical costs for installation of a single trunk cable (including cable cost) are as follows (all prices are per mile):

Annual Costs

| | |
|-------------|--------|
| Pole Rental | \$ 160 |
| Power | \$ 40 |

Cable and Installation Cost

Aerial* \$ 7,500

Underground**

Business District \$35,000

Rocky Area \$25,000

Normal and Sand Area \$20,000

* Aerial cable drops are approximately \$50 each.

** Underground costs include vaults, pedestals, and conduit.

As can be seen from the above figures, the approximate installation costs for aerial cable are \$1.50 per foot, and for underground cable are \$5.00 per foot (in conduit). Direct burial underground cable installed with a trenching machine averaged \$1.50 per foot.

SECTION IV

HUB SWITCHES

The switching hub provides a means for economical equipment interconnectivity within local areas, while minimizing traffic flow on trunk lines. Hub areas would contain an assemblage of equipments that are accessible on a time-shared basis. A schematic diagram for a typical system including hub equipment with a broadband switch is shown in Figure 8.

Among the factors considered in the selection of a switch are: types of signals to be switched, single or multiple switching requirements, switch closure sequences, modularity, and electrical characteristics.

BROADBAND SWITCH CHARACTERISTICS

It was anticipated that the initial investigation within the basic experimental facility would cover the frequency range from DC to the VHF band. This would permit a wide range of evaluations from direct hard-wired connectivity on a point-to-point basis at baseband frequency at the low end of the frequency spectrum, to evaluation of the distribution of VHF video channels at the high end.

From a market survey of available video switches that was conducted, it was determined that video switches can be divided into two basic categories: single output switching - switching one or more inputs to a single output buss, and multiple-output switching - switching one or more inputs to more than one output buss. Each group can be further categorized by considering the quality of switching required and the location of the switch matrix in relation to the location of the switching controls.

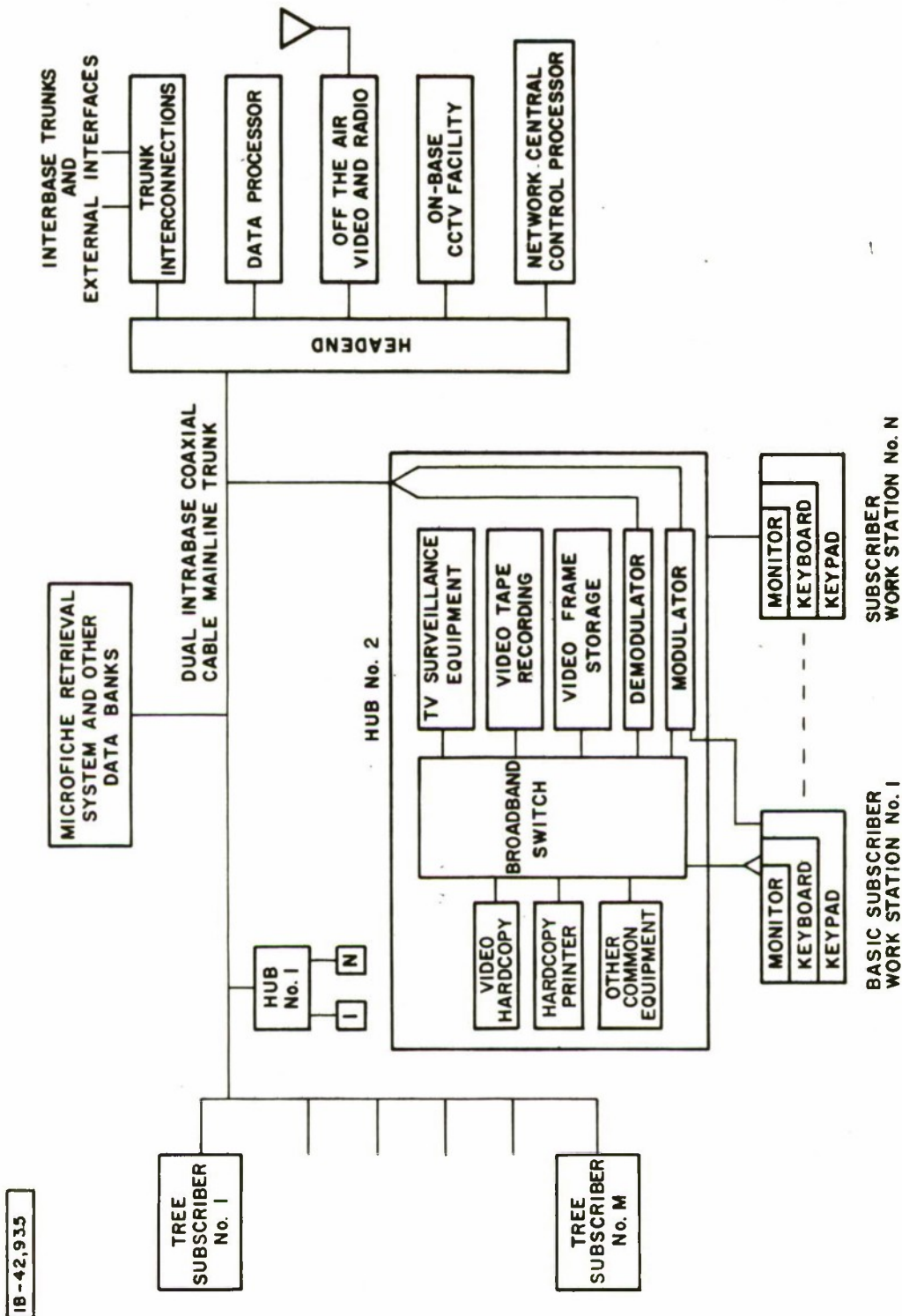


Figure 8 AFBITS EXPERIMENTAL EVALUATION SYSTEM SCHEMATIC

The quality of the switch is influenced by the type of signals that are to be switched and the type of switching action that occurs. Although the switch was required to handle video frequencies, there was not a requirement to perform synchronous video switching such as would occur with multiple TV camera studio generation of video information. Because of the non-synchronous nature of the information, typical video switch requirements, such as gap switching, lap switching, and vertical interval switching, need not be considered. However, the electrical characteristics of video switches are of great importance and were considered in detail.

The majority of video switches operate within a frequency passband of 60 MHz. The upper frequency limit, from a practical point of view, is currently about 100 MHz. The switches considered had a bandwidth of 60 MHz or greater and exhibited an RF switching capability wherein the Voltage Standing Wave Ratio, noise figure, intermodulation and harmonic distortion figures were low, while the signal isolation was high.

In addition to good electrical characteristics, the switch design must also incorporate a modular expansion capability and a means of being remotely controlled by digital techniques.

Two broadband switches were purchased for evaluation and integration into the facility: one representative switch each of the 60 and 100 MHz class.

Broadband Switch C

Broadband Switch C was a typical state-of-the-art matrix switch useful in applications where the frequency range extends from DC to 60 MHz. The basic switching module consists of a single package of 50 matrix-mounted reed switches organized in a $5 \times 10 \times 1$ array of crosspoints. Crosspoint latching information, which is electronically TTL logic signal compatible, is stored in integrated

circuit flip-flops. The outputs of the storage register are used to drive electromagnets which in turn latch reed relays. Any number of combination of crosspoints can be latched or unlatched without affecting the condition of other crosspoints in the matrix. Per unit cost was approximately \$18 a crosspoint. In Figure 9 the reed relays and electromagnets of a typical matrix switch are shown. The 19" wide x 14" deep x 2" high module was designed to be mounted in a standard relay rack.

Broadband Switch M

Broadband Switch M was a reed relay type of matrix switch that is useful in applications from DC to 100 MHz. The basic switch module consists of an array of 50 reed relays organized in a 5 x 10 x 1 array of crosspoints. Four basic assemblies are installed into a rack mountable tray (approximately 19" wide x 16½" deep x 5¼" high) to provide a 10 x 20 x 1 crosspoint capability. The system is expandable and digitally addressable up to a configuration of sixteen trays. The construction is such that components are contained within very rugged machined-aluminum housings which provide for a high degree of shielding between signal busses and very low signal radiation. Electrical operation is similar to that of Switch C. Per unit cost was approximately \$25 a crosspoint.

MEASUREMENTS

Five electrical measurements were performed during the evaluation of each switch; crosstalk, isolation loss, insertion loss, bandwidth measurements, and coil-induced noise.

Crosstalk

An important characteristic of the switch is the ability to minimize interference between the various channels within the switch. Undesired signals induced from adjacent channels can cause errors in data transmissions or crossview and associated video bars

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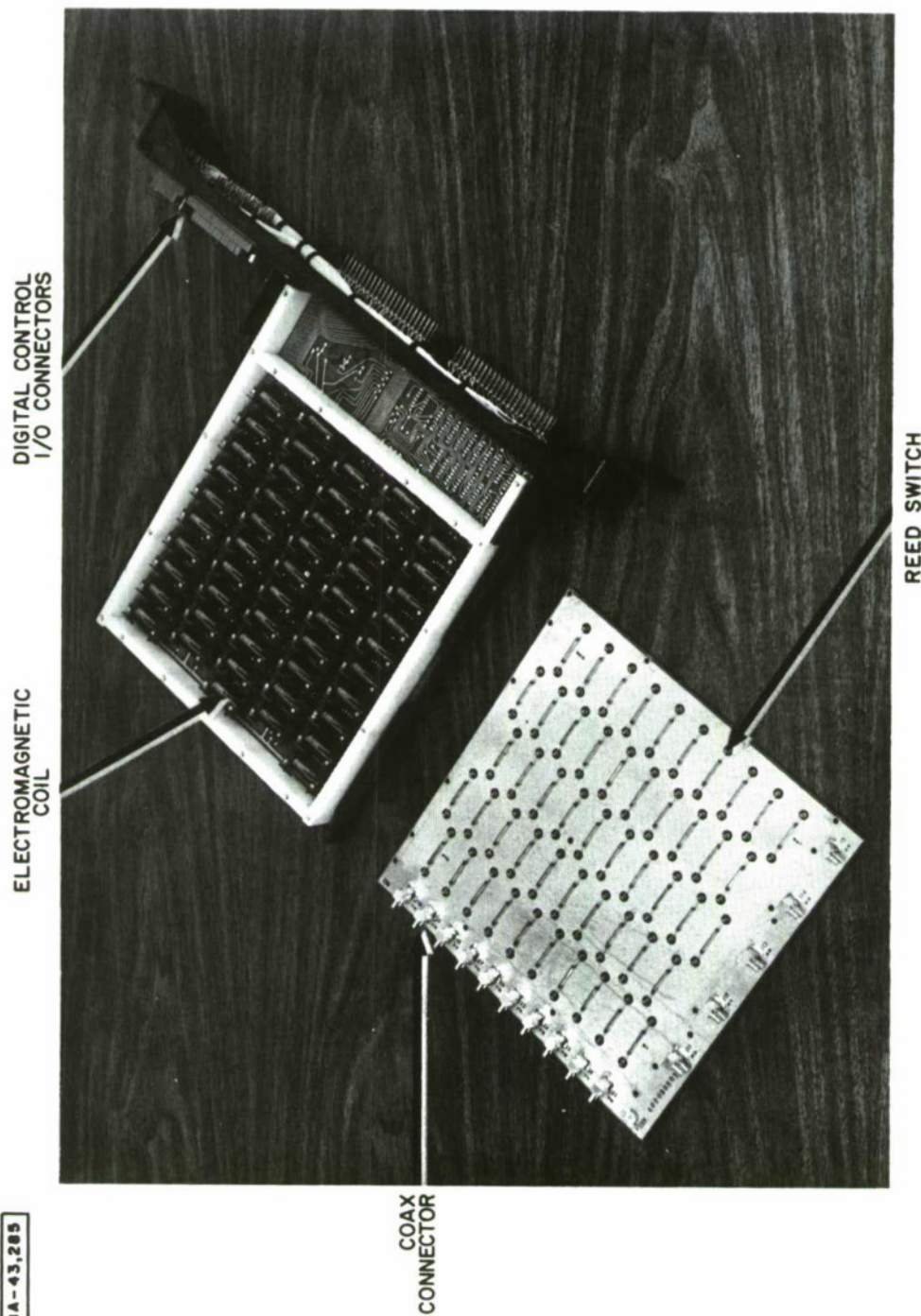


Figure 9 BROADBAND MATRIX SWITCH

in video transmissions. An important specification of the switch is the amount of crosstalk that can be tolerated. The crosstalk measurement was made by connecting the appropriate instruments, as shown in Figure 10A, and applying a sine wave to the desired path at the frequencies and amplitudes of interest. The amplitude of the signal that is coupled to the adjacent path of interest was measured. The crosstalk was computed as: $db = 20 \log V_1/V_1$. Typical crosstalk measurements obtained were:

| | |
|----------|------------------|
| Switch C | -60 db at 50 MHz |
| Switch M | -56 db at 50 MHz |

Isolation

An isolation measurement is necessary to determine the amount of signal that is coupled from a signal bus, across an unlatched set of contacts, to an output bus. As shown in Figure 10B a sine wave was applied to the desired latched path at the frequencies and amplitudes of interest and the signal amplitude measured and recorded. The matrix switch path was then unlatched (Figure 10C) and a terminator added to the signal generator input. A second measurement of signal amplitude is then made across the output of the open contact. The contact isolation was computed as: $db = 20 \log V_1/V_2$. Typical isolation measurements obtained were:

| | |
|----------|------------------|
| Switch C | -48 db at 50 MHz |
| Switch M | -58 db at 50 MHz |

Insertion Loss

The amount of signal loss incurred by insertion of a device in series with the signal path must also be considered. It is desirable to have as little insertion loss as possible in order to eliminate the need for external compensation. Insertion loss measurements were made as shown in Figure 11A. A signal from a

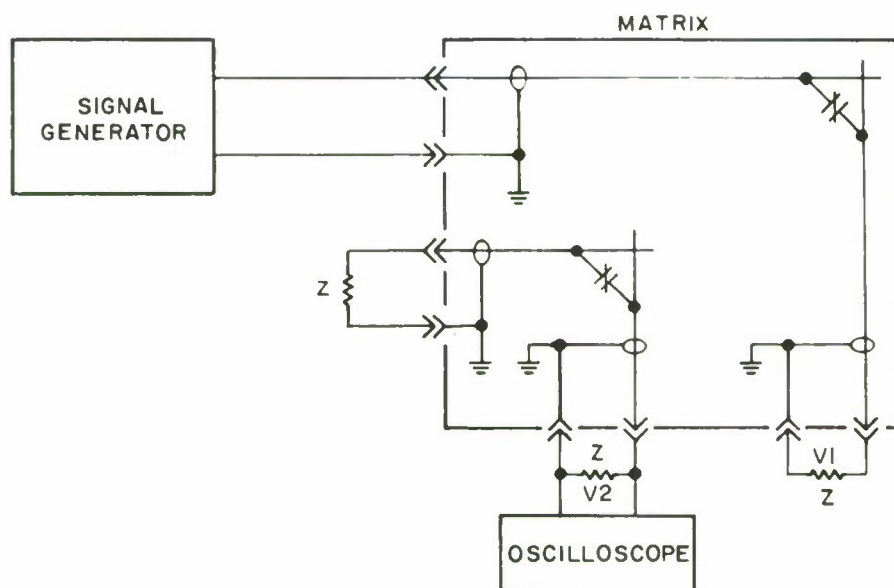


Figure 10A CROSSTALK MEASUREMENT

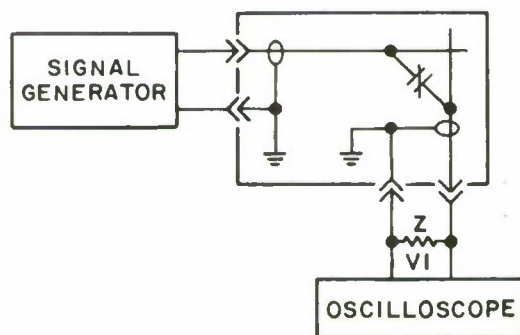


Figure 10B

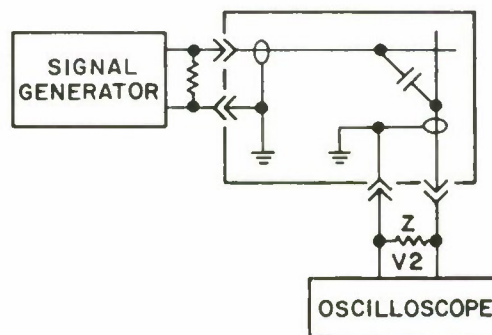


Figure IOC

ISOLATION MEASUREMENT

Figure 10 CROSSTALK AND ISOLATION MEASUREMENTS

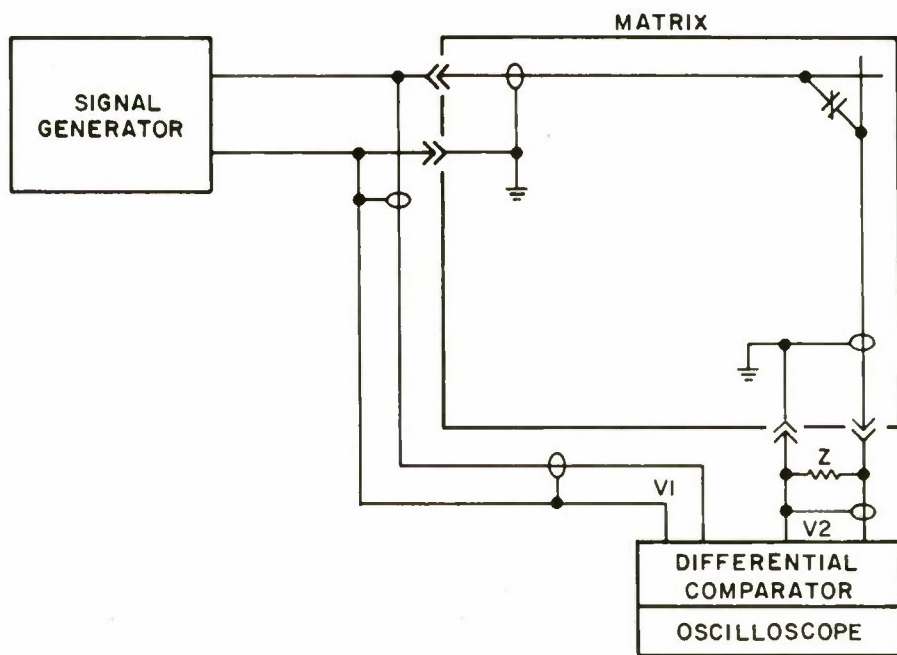


Figure IIA INSERTION LOSS MEASUREMENT

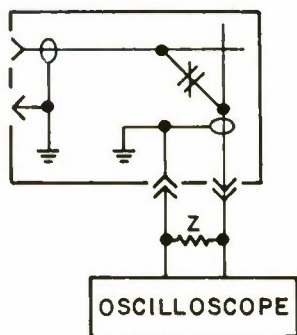


Figure IIB COIL INDUCED NOISE

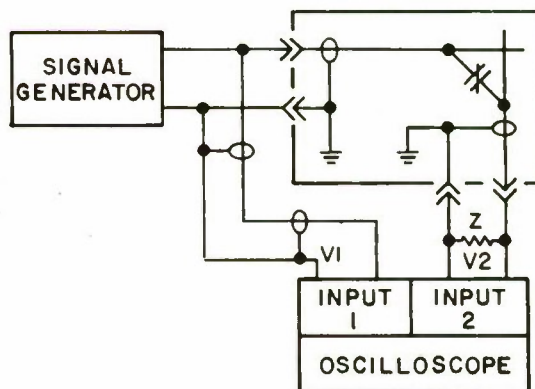


Figure IIC BANDWIDTH MEASUREMENT

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Figure II. INSERTION LOSS COIL-INDUCED NOISE, AND BANDWIDTH MEASUREMENTS

generator is applied at the input to the switch and the input and output voltages are sampled through a differential comparator. The insertion loss was calculated as $db = 20 \log V1/V2$. Typical insertion loss measurements were:

| | |
|----------|-----------------------------------|
| Switch C | 1.8 db at 60 MHz and 10 m v input |
| Switch M | 2.6 db at 60 MHz and 10 m v input |

Bandwidth

Bandwidth measurements, which are an extension of Insertion Loss measurements over a range of frequencies, were made as shown in Figure 11C. A signal generator supplied a sine wave signal at the frequencies of interest to the input of the matrix. The input and output of the signal path were measured and the bandwidth was computed as: $db = 20 \log V1/V2$. Several measurements were made using different paths through the matrix switch. Typical response curves for both broadband switches are shown in Figure 12.

Coil - Induced Noise

Measurements of induced noise caused by the remote switching circuitry and contact closures were also made with test equipment configured as shown in Figure 11B. A crosspoint of interest was slowly pulsed on and off, by alternately energizing and de-energizing the crosspoint relay coil, and a measurement of the noise induced in the associated matrix paths was made. The worst case induced noise in both switch types was less than 80 microvolts.

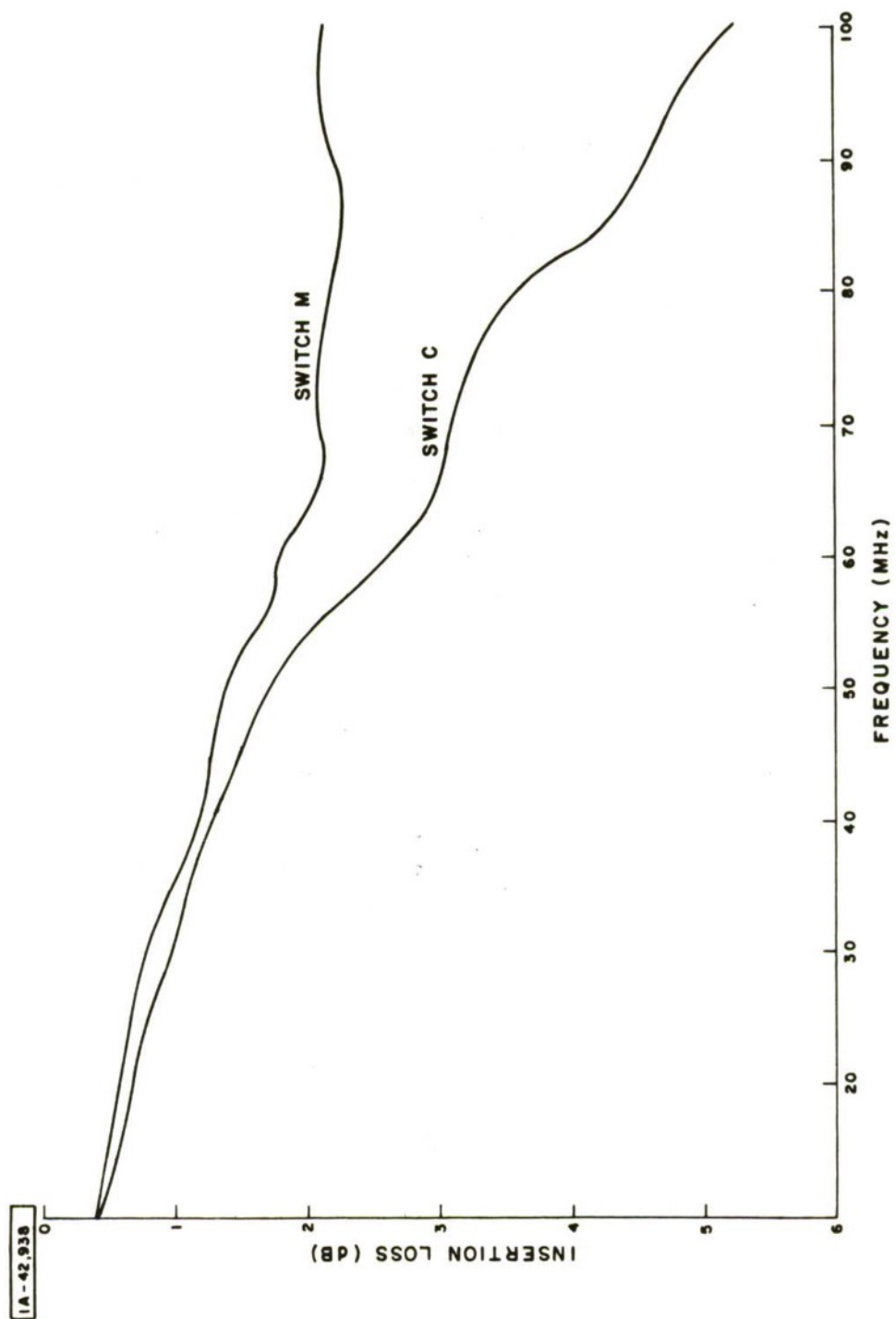


Figure 12 BROADBAND SWITCH BANDWIDTH CURVES

SECTION V

TERMINAL EQUIPMENT

An important aspect of the AFBITS experimental effort has been the technical and operational evaluation of user work station configurations for the generation and transfer of administrative and logistic support type information on Air Force bases.

This section describes the characteristics of the various terminal equipments that were used in the evaluation configuration. Only those equipments that directly interfaced with and were dedicated to the work station are described here. Characteristics of common equipments that operated on a time-shared basis are described in Section VI, while the results of the operational combination of the equipments are described in Section VII.

BASIC TERMINAL

In the interest of evaluating the least expensive type of work station possible a basic work station configuration was assembled consisting of a monitor for viewing alpha-numeric and video information, a keyboard for data entry, and a keypad for entry of connectivity data (Figure 13).

Keypad

The keypad used to set up connectivity consists of an array of twelve momentary contact push buttons arranged in a 3 x 4 layout similar to that of a telephone Touch-Tone dial-up pad and is one component of the Network Access and Status Device (NASD). The NASD (Figure 14) is used for entry of connectivity data to the Network Central Control Processor (NCCP). Connectivity codes consist of a start character and four digits. Keypad contact closure information is converted to ASCII code within the



Figure 13 BASIC SUBSCRIBER WORK STATION

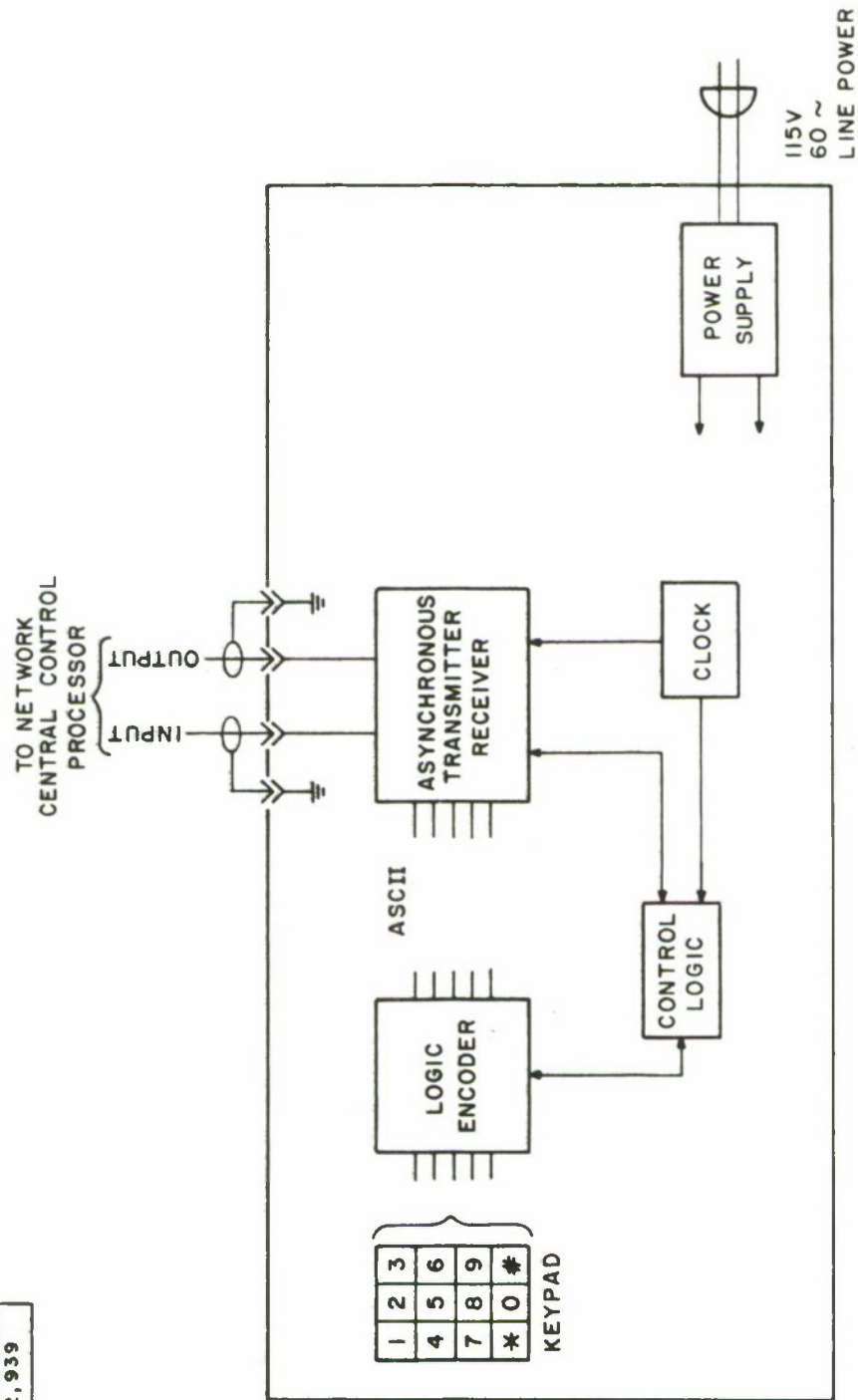


Figure 14 NETWORK ACCESS AND STATUS DEVICE

keypad electronics and is then transmitted serially, at 110 baud, over coaxial cable to the NCCP. The NASD electronic designs and packaging were completed in-house.

Keyboards

Free-standing keyboards were used to enter alphanumeric data information. The keyboards were modified in-house to be self-powered and contain the necessary electronics to encode and convert keystroke information into a serial RS-232 compatible output over a single coaxial cable.

Keyboard A

Keyboard A was a KSR33 Teletype equivalent consisting of 53 keys which could generate 64 upper case alphanumeric ASCII characters. Keystroke movement was converted into electronic information by closure of a reed relay contained within the housing of each key-stem. Although serial data output from the interface electronics was constrained to be 110 baud (approximately 11 keystrokes per second), the interface provided an N-key rollover buffer which would save for transmission those data inputs that are generated in excess of 11 keystrokes per second.

Keyboard L

Keyboard L contained 52 keys from which a full set of 96 ASCII coded alphanumeric characters could be generated. The self-contained keyboard utilized ferrite core (magnetically operated) switches, which are contactless in operation, as the means of converting keystroke inputs into electronic signals. An N-key rollover buffer was included in the interface to insure against lost information by a fast typist. Additionally, the keyboard contained a 12 button calculator type keypad for quick entry of numeric data.

Monitors

In order to provide a work station configuration with maximum utility the video monitor should be capable of displaying standard and high resolution video for viewing the pictorial material as well as being able to display alpha-numeric characters generated by either a local or remote character generator when dealing with textual material.

Various types of monitors were evaluated in conjunction with viewing different classes of video information. Included in the facility were representative monitors that operated at frequencies and bandwidths ranging from the commercial television standards to those required for high resolution reproduction.

Monitor HP

A large number of work station applications such as television surveillance, video training film retrieval, and non-correspondence character generation, could be satisfied by a monitor constructed to standard commercial television specifications. Monitor HP was used for this class of video viewing. The monitor was a standard 6 MHz channel, 525 line, 60 fields per second television receiver with a 12 inch white phosphor viewing screen. A modification was made in-house to permit operation with a composite video signal input at baseband frequencies. Typical monitor resolution of a televised standard test pattern was 300 vertical lines and 275 horizontal lines.

Monitor CENA

For work station configurations that require the capability of displaying sufficient line data so as to be useful for correspondence preparation, and the capability of being video compatible with commercial television standards, a medium resolution monitor was employed. Monitor CENA was of the 10 MHz bandwidth class which

operated at standard 525 line, 60 fields per second rate. The black and white, standard phosphor monitor had a resolution of 500 or greater lines over the horizontal viewing area. The relative cost, because of its lower production quantity, is approximately twice that of a standard television set monitor.

Monitor CCQF

Remote video retrieval of microfiche information at a work station required a monitor with high resolution capability. Monitor CCQF was a 30 MHz, 1029 line, 60 field per second high quality monitor whose characteristics are typical of the 1000 TV line class of monitors. The 14 inch black and white display could resolve 750 lines or greater across the viewing area. Relative cost is approximately three times that of medium resolution monitors.

Monitor CRQA

Some work stations will require a basic terminal with the flexibility of displaying, on a one at a time basis, standard 525 line television information, high resolution correspondence data, or high resolution microfiche retrieval information. The display of the various classes of information could be achieved by dedicating one each of the three previously described monitors to each class of information. A more economical solution would be to use one monitor with a built-in switching capability that could selectively switch its operational characteristics to match those of the incoming signals. Monitor CRQA was representative of a new class of production monitors that can be interfaced with variable video input scan rates. The 14 inch black and white monitor was designed to provide automatic and independent line-rate and field-rate sensing of incoming signals and acquire automatic sync on the frequency of the signal. Internal controls in the monitor allow it to be preset to any two line rates so as to provide the proper aspect ratio to the viewer. For

operation as a component of the basic terminal, the monitor was preset to acquire sync on 525 line and on 1029 line video signals. The relative cost of the monitor is twice that of a fixed frequency high resolution monitor. This self-adapting monitor is shown in the subscriber work station configuration in Figure 15.

STAND-ALONE TERMINALS

Stand-alone or so called intelligent terminals are those which contain an integral character generator and refresh memory and sufficient data processing capability to be used for message or text preparation on a stand-alone basis without need for connection to an external data source. Such terminals are required where limited communications and/or equipment sharing capability exists such as in a tree configuration. Two stand-alone terminals were included in the experimental configuration to evaluate the feasibility of including a limited, wired or pre-programmed, correspondence operating terminal at tree locations as a trade-off against providing multiple channel connectivities over the coaxial cable for the performance of the same function. One terminal is classified as a wired-program smart terminal, and the other as a programmable intelligent terminal. Typical stand-alone soft copy terminals are shown in Figure 16 along with an I/O typewriter and a NASD.

Terminal D

Terminal D was a self-contained stand-alone unit consisting of an integrated data-entry keyboard, video display, character generator and refresh memory, control and transmission line interface logic, power supply and a dual magnetic tape unit.

The 92 key keyboard was divided into two sections: 12 keys configured in a calculator layout for quick entry of numeric information, 7 keys in a format to permit quick cursor maneuverability, and 73 keys configured in standard typewriter format plus

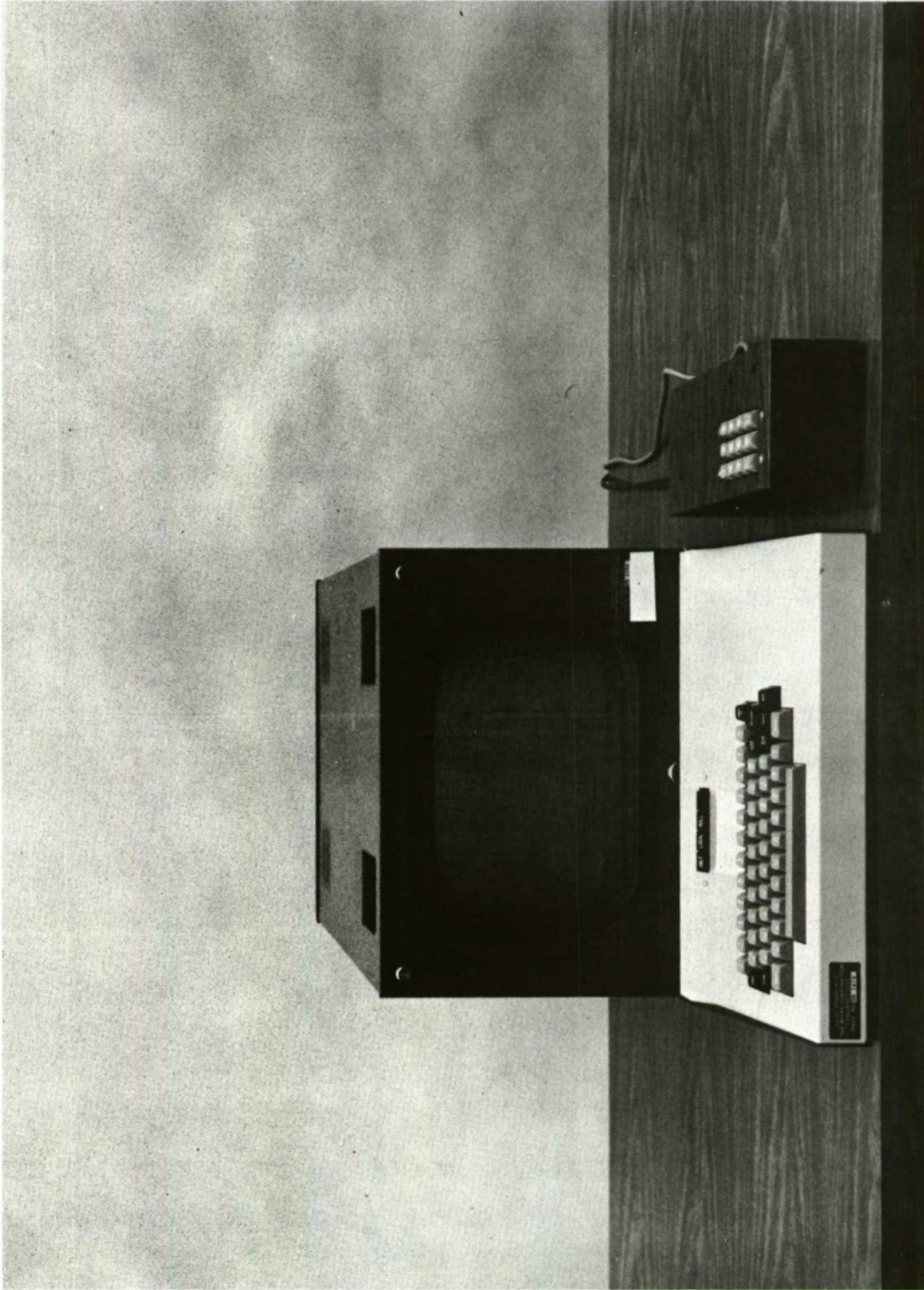


Figure 15 WORK STATION WITH SELF-ADAPTING MONITOR



Figure 16 STAND-ALONE TERMINALS AND I/O TYPEWRITER

control keys from which all 96 ASCII upper and lower case alphanumeric characters and selected additional control codes could be entered. The keyboard was color coded to permit quick identification of data and control entry keys.

A 14 inch video monitor capable of displaying 2160 alphanumeric characters in a 27 line by 80 character per line format was incorporated into the terminal as the viewing device. The basic monitor was a 525 line, 10 MHz bandwidth television receiver with a green phosphor (P31) viewing tube and, with the exception of the phosphor, was equivalent to Monitor CENA previously described.

An ASCII upper and lower case character set of 96 alphanumerics could be generated and displayed on the monitor in a dot matrix fashion in which each character was contained within a 7 by 9 dot matrix field.

The basic operation of the terminal was controlled by a built-in wired program which, because of its capabilities, placed it in a category between dumb terminals - those that generate and transmit data only and rely on externally generated control codes for formatting, and the intelligent terminals - those that contain a built-in microprocessor capable of being programmed. Terminal D was hard-wired programmed to perform a small number of text editing and formatting operations in which the edit capability was limited to character insert and delete, and line insert and delete.

The format capability allowed information to be placed in pre-established locations on the viewing screen: these locations were either fixed data fields or variable fields. A fixed data field was under operator control and permitted the entry of non-destructible data, such as header information on a personnel record, to serve as a guide for the insertion of the variable data. The variable data field contained the subject information.

A paging feature, that was hard wired into the terminal, permitted the viewing of only a segment of the information in the terminal memory. The memory could contain up to 3071 characters but the monitor was capable of displaying a maximum of 2160 characters at any one time. The paging feature permits the viewing area to act as a window and slide over the entire contents of memory and, at any given point, display a maximum of 27 lines of information. In addition, the paging feature allowed an elasticity of memory line storage that was not constrained to 27 lines of 80 characters per line. For example, when an operator wrote an average of 20 characters per line, the memory could handle 153 lines of information ($20 \times 153 = 3060$ characters) and the paging feature would permit scrolling of the display between line 1 and line 153 on a line by line increment with 27 lines of text in view.

Terminal K

Terminal K was a self-contained microprogrammed intelligent terminal that was used to investigate the feasibility of incorporating complex text editing capabilities and preprogrammed format capabilities into terminals associated with tree configurations. The principal components of the terminal were keyboard, display, control and interfacing electronics, and a dual cassette tape drive.

The keyboard contained 83 keys arranged into three distinct groupings; 58 keys configured in a standard ASCII keyboard (typewriter) layout, 13 keys in a function key/cursor control group, and 12 keys in a conventional calculator numeric data entry group. The key tops were coded in either of two-colors to permit rapid distinction between alphanumeric data entry keys, and control and function keys.

The monitor consisted of a 14 inch black and white display with a conventional TV phosphor. Character display format on the viewing

screen was 25 lines of up to 80 characters per line for a total of 2000 characters. Character font was made up from a character generator which had a 96 ASCII upper and lower case character dot matrix generating capability in a 9 by 13 array of dots.

The terminal memory system contained a 1024 word Read Only Memory (ROM) for use by the Firmware Operating System (FOS), which, when operated in conjunction with a host computer, served as the primary programming tool for the development of the application programs. The application programs were contained within an additional 1024 word Random Access Memory (RAM) module. The display refresh and buffer memory was a 2048 word RAM module.

Application programs and preprogrammed display formats that were developed for use in the terminal were stored on a magnetic tape cassette in the attached dual cassette system.

HARD COPY SEND/RECEIVE TERMINAL

The experimental configuration also included a hard copy send/receive terminal (Figure 16) that was basically an automated electric typewriter that could be used either as a conventional typewriter, a transmit keyboard, or a receive only printer. The terminal consisted of three principal components: a modified electric typewriter, electronic control for the device, and interface electronics.

The typewriter was an IBM Selectric II Typewriter that was commercially modified to include a buffered applique within its base that enabled it to code convert keyboard strokes to electronic information and conversely, to receive and convert electronic

information into print commands. Being an IBM Selectric mechanism, it retained the features commonly found in that typewriter - interchangeable type elements, interchangeable ribbon styles, selective 10 or 12 pitch spacing, and multiple line feeds. Maximum automatic typing rate was approximately 15 characters per second; however, the data interface rate was 110 BAUD (approximately 11 characters per second).

This send/receive terminal, as purchased, was a parallel interface device and contained no provision for serial data exchange. Since the data transmission technique required a serial by character, serial by bit data exchange, an in-house serial/parallel converter and coaxial line interface unit was constructed.

SECTION VI

COMMON USER EQUIPMENT

In an AFBITS configuration all work stations within an area will not necessarily be simultaneously performing work tasks that require identical equipment configurations. Some subscribers will be generating correspondence, some viewing video material, and others performing off-line operations. Therefore, it becomes economical to share certain types of low usage and relatively expensive equipment. The variety of operational applications and the built-in system connectivity and resultant flexibility of the switched hub make this approach attractive.

In this section, the characteristics of such common user video and data retrieval equipments and copy devices are discussed.

HARD COPY PRINTER

In many operational configurations involving soft copy correspondence preparation, there will, at least for the foreseeable future, be a requirement for hard copy output. In order to evaluate meaningful system equipment configurations and the resultant transmission system requirements, a low speed hard copy printer was included as part of the evaluation configuration (Figure 17). The receive only serial printer used was selected because of its print speed, print quality, and simplistic mechanical design.

A serial to parallel data converter was installed at the input interface to accept 300 baud serial asynchronous character and control information and transform it into a parallel format as required by the printer hardware. Maximum print rate for the evaluation was 30 characters per second. A correspondence typing font containing 96 upper and lower case characters molded into a

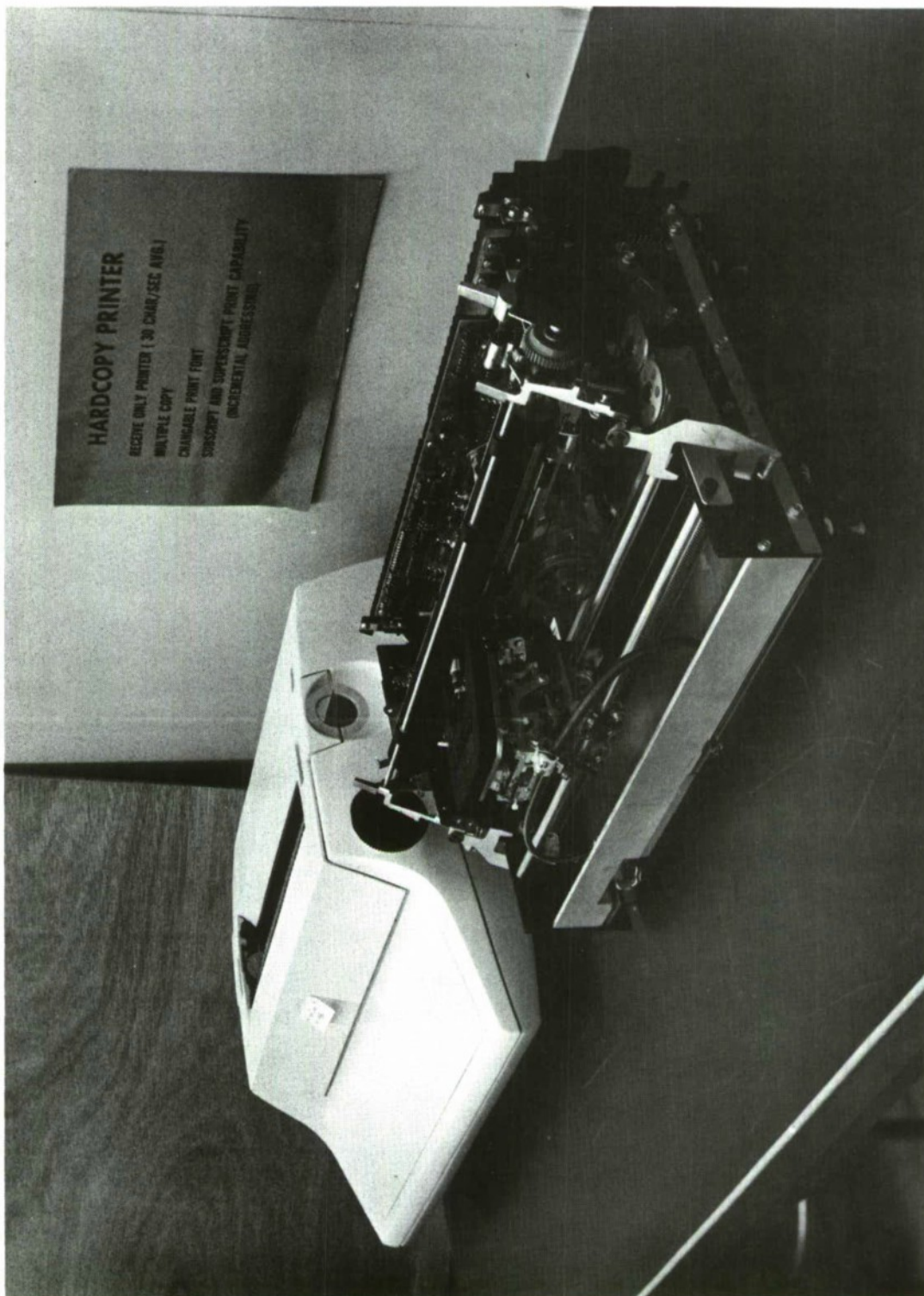


Figure 17 LOW SPEED HARD COPY PRINTER

printing element was operator removable to permit the inter-changing of various style character fonts. Character impressions could be transferred from print head to paper by either cloth ribbon or one-time ribbon, both of which were available in cartridges.

With the proper controller interface the printer can be proportionally spaced both in the vertical and horizontal directions, a feature which is desirable for text preparation involving superscripts, subscripts, and justification.

The mechanical design of the paper and ribbon feed, the character and column selection mechanism, and the impact device contained a minimum of moving components. In an operating mode the acoustic noise factor of the printer was significantly less than that of similar typewriter output printers.

CHARACTER GENERATOR/REFRESH MEMORY

A combination character generator/refresh memory was included as part of the common equipment to allow remote data entry keyboards the capability of storing and converting digital information into a form suitable for video display. The character generator would accept standard ASCII characters in an RS-232 format at a 110 or 300 baud rate and provide storage for up to a maximum of 512 characters in a 16 line by 32 character per line format. Character repertoire was limited to the 64 ASCII upper case alphanumeric character set. Character size, which was proportional to viewing screen size, was approximately $\frac{1}{4}$ inch on a 9 inch screen and was defined by a 5 x 7 dot matrix in an 8 x 12 dot field.

Output information from the character generator/refresh memory was available as RS-232, video, or RF signals. The RS-232 compatible output operated at the same baud rate as the input data, (110 or 300 baud). Information for direct transmission to a conventional

525 line, 60 frames per second, 4 MHz television receiver/monitor was available as baseband video and modulated RF pretuned to a standard VHF TV channel frequency.

The self-powered stand-alone character generator was contained within a 15" x 6" x 6" chassis.

LOCAL VIDEO SURVEILLANCE/STILL PICTURE TRANSMISSION

To investigate the practicality of multiple channel transmission of a variety of video signals, several video generating sources were used. For fixed viewing surveillance of a predetermined area or for document/map transmissions, commercial 525 line 4 MHz bandwidth black and white television cameras were used. The vidicon cameras had a standard composite video output which could be selected to be at baseband frequency or standard TV channels 2 through 6. The lens system, a 25 mm F1.8 lens, was preset to a fixed aperture and fixed focus. Resolution at the center of the vidicon was in the order of 325 lines. The cameras could be remotely up to 1000 feet with type RG-59 coaxial cable or 2000 feet with type RG-11 low loss coaxial cable without additional amplification.

REMOTE VIDEO SURVEILLANCE

A remote controlled video surveillance camera was also included as part of the experimental configuration. The camera presented the class of problem that required video acquisition of the transmitted information on one subscriber channel and the transfer of subscriber keyboard control information on another channel. The camera installation consisted of a standard 525 line closed circuit TV camera with a remote controlled zoom lens. The camera was mounted in a weatherproof enclosure which in turn was mounted on a remote controlled pan/tilt assembly installed on a building

roof-top (Figure 18). The remote controlled features of the motorized lens provided a zoom ratio of 4 to 1 as well as a motorized focus and iris control. The pan/tilt assembly allowed for the remote positioning of the camera from 0° to 360° in azimuth and $\pm 45^{\circ}$ in elevation.

VIDEO STORAGE

Several equipment applications will require a form of video storage either on a continuous picture basis or a single frame basis. Three types of video storage devices were included in the evaluation: a video cassette recorder, low resolution video frame storage device (framegrabber), and a high resolution video frame storage device.

Video Cassette Recorder

The video cassette recorder/player was provided to illustrate the capabilities of video taping and replaying of training programs, briefings, etc. The recorder could be accessed either on an individual subscriber basis or on a broadcast basis and had sufficient bandwidth to permit color reproduction where necessary. A two head helical scan recording system was used to record EIA compatible video information on a 60 minute playing time cassette. The record electronics could be pretuned to any standard VHF or UHF TV channel, or direct baseband video could be used as an input. The output signal could be selected to be either modulated RF at a TV channel frequency or direct baseband video. Additionally, there were two audio channels available to provide flexibility in programming. One such application for the audio channels could be bilingual recording. Overall horizontal resolution for a monochrome recording was in excess of 300 lines. The video cassette recorder is shown in Figure 19.

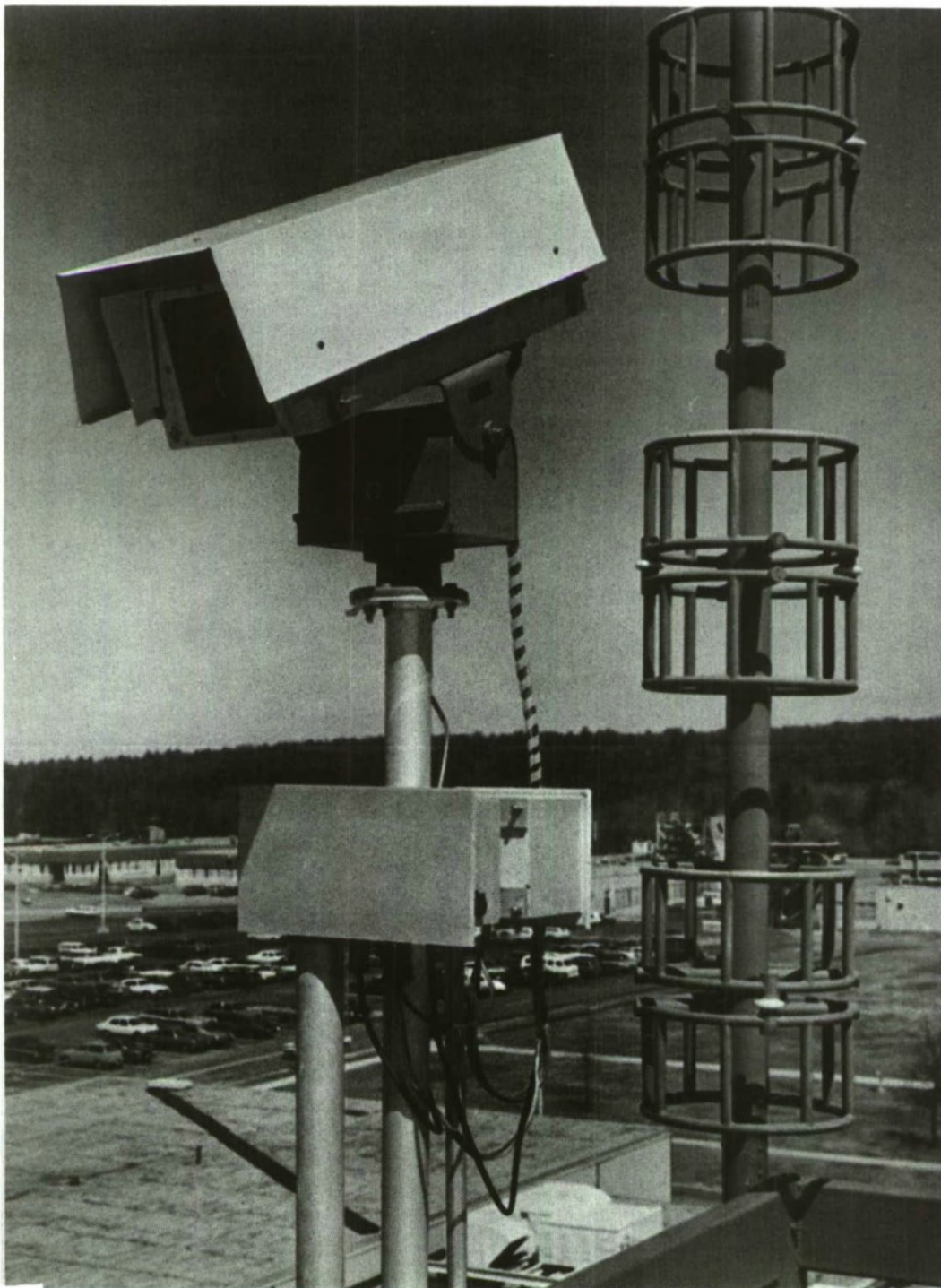


Figure 18 REMOTE CONTROLLED VIDEO SURVEILLANCE CAMERA

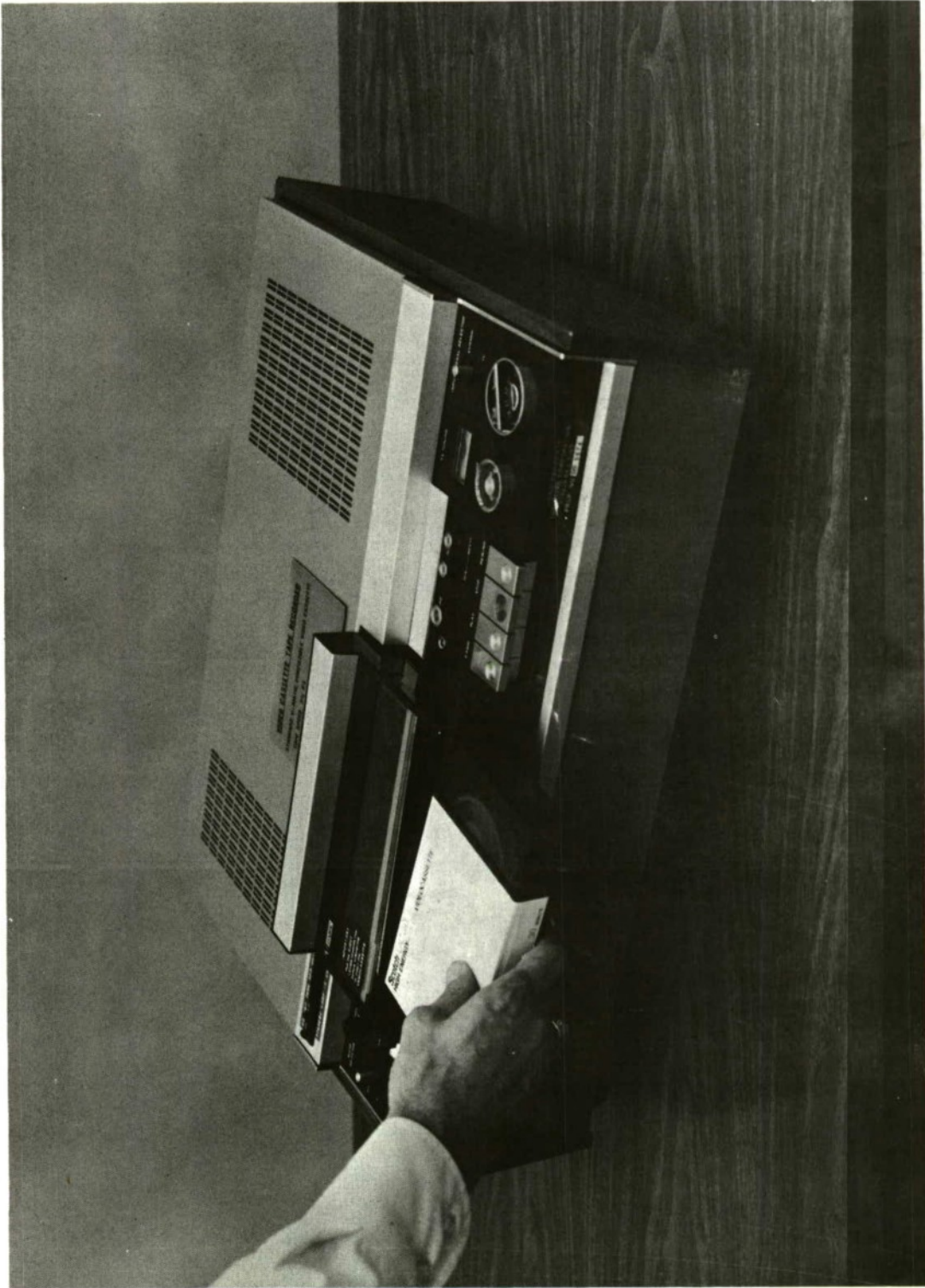


Figure 19 VIDEO CASSETTE RECORDER

Video Frame Storage

Video frame storage framegrabbers are an important element in an operational information exchange system. Video frame storage makes possible the time sharing of various user equipments thus allowing the cost of expensive equipment to be shared among many subscribers. For example, in a video retrieval system with centralized files, a static image, after being accessed, could be held in video frame storage thereby releasing the retrieval system to other subscribers. Two types of video storage devices were included in the experimental configuration: a rotating magnetic disk, and an electronic storage tube.

Low Resolution Video Frame Storage

There has been a multitude of magnetic storage devices on the market for years in the form of magnetic tape recorders and magnetic disk recorders. Most video magnetic tape devices have been designed for storage of continuous video information whereas video disk recording devices, because of the limited storage capability and higher access rates, are usually designed to store a small number of video frames. In general, video frame disk storage systems have been of such expense (in the order of ten thousand dollars or greater) that their use in information transfer systems was very restricted. However, because of technological advances and a requirement to design the quality of the storage device to only be compatible to that of the reproducing device, a new generation of inexpensive video storage devices is being produced and marketed.

For low resolution video storage in the experimental configuration, a four inch magnetic disk system was used which had the capacity to record and reproduce one video frame of information. The disk (Figure 20) was revolved at the TV field rate of 60

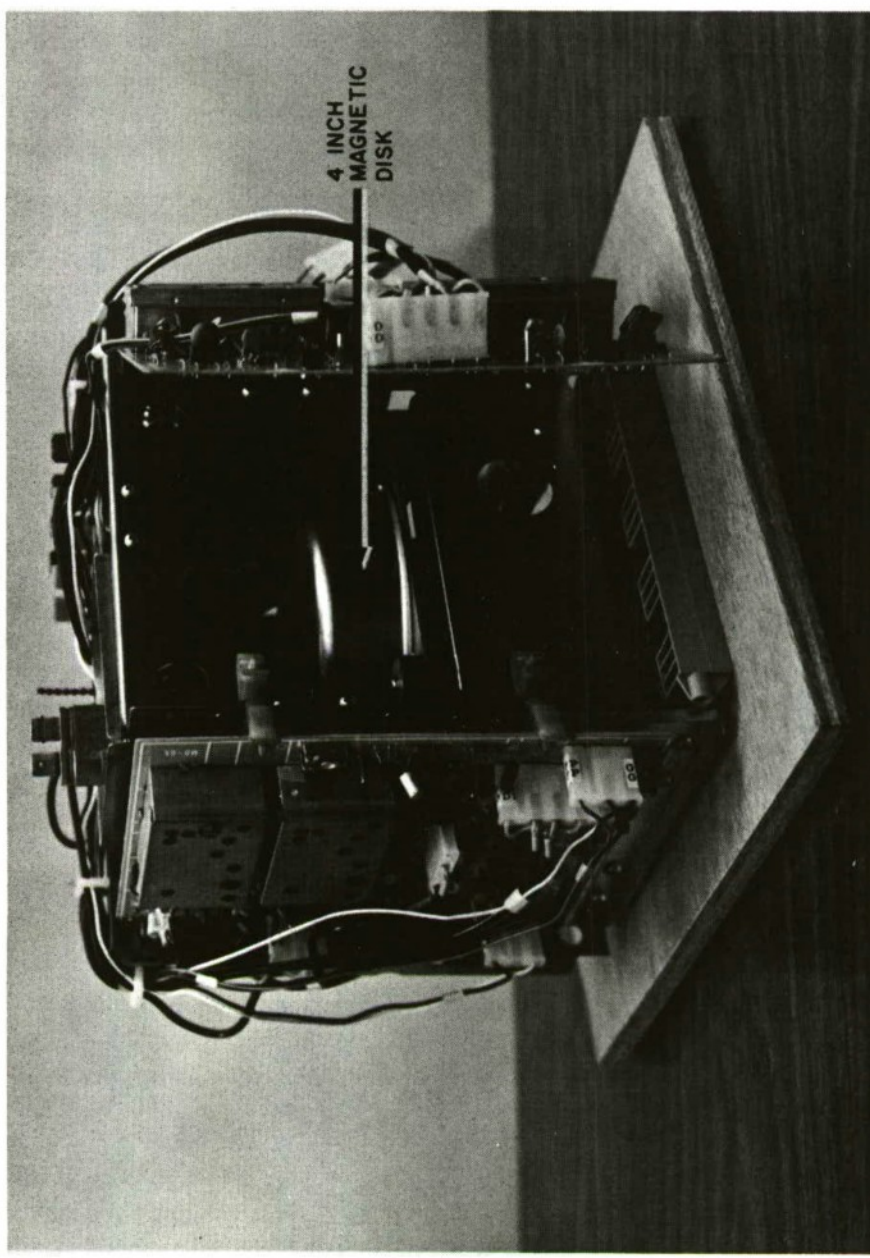


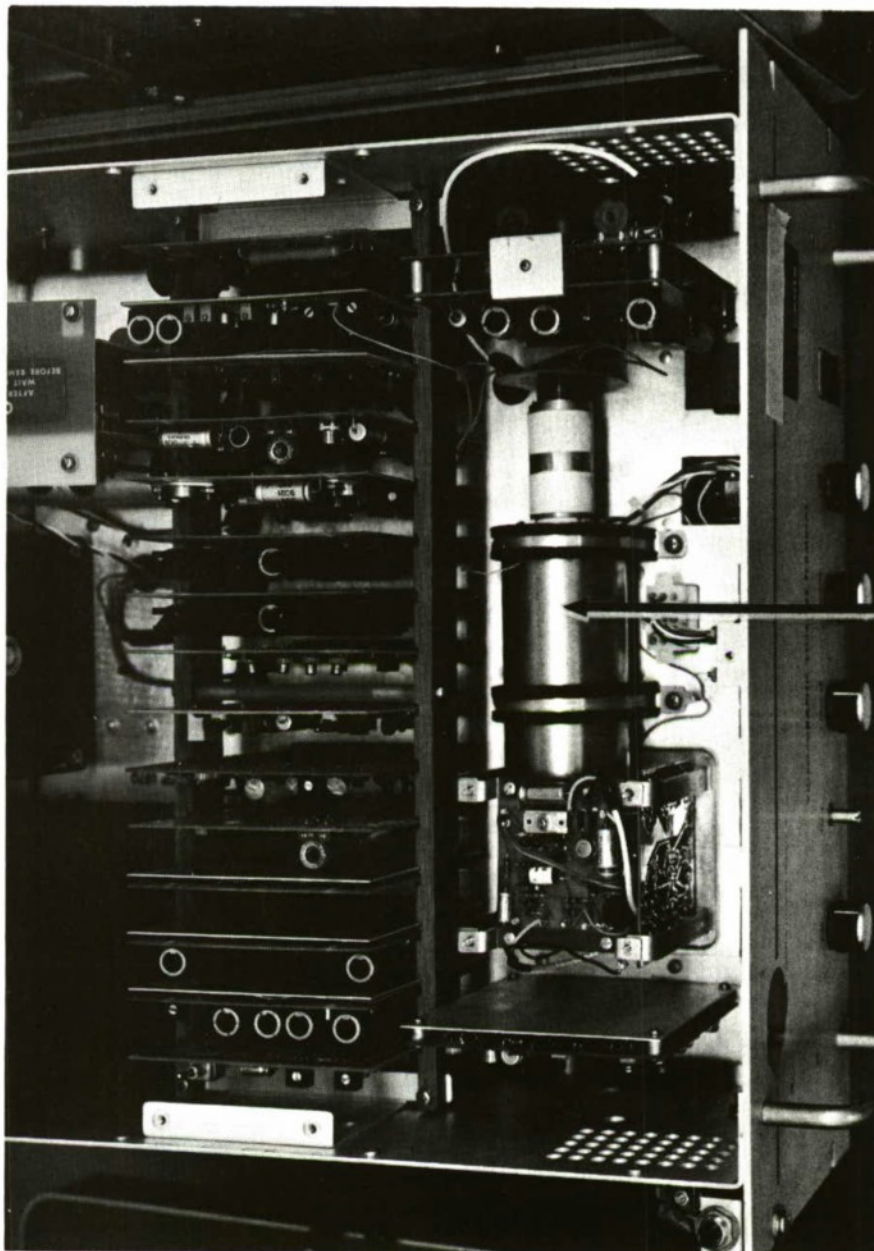
Figure 20 LOW RESOLUTION VIDEO FRAMEGRABBER

revolutions per second (3600 RPM) by a single-phase hysteresis synchronous motor. Video bandwidth of the recording channel was approximately 5 MHz at the 3 db point; however, the overall resolution based on the reproduction of recorded information was approximately 200 lines horizontal and 250 lines vertical. The trade-off for low resolution was low cost which, on a per unit basis, was approximately the same as for a high quality black and white TV receiver.

High Resolution Video Frame Storage

High resolution video storage could be accomplished using disk techniques; however, the cost would be excessive. Several electronic devices commonly called storage terminals, scan-converters, or framegrabbers are now available at a moderate cost (currently \$3000 to \$5000). To provide for versatility in the investigation of storage devices, and to economize the total equipment cost, an electronic storage device (Figure 21) was chosen for high resolution video storage in the experimental configuration. The storage medium was a silicon storage tube that was operated at a 1029 line scanning rate with its associated video circuitry which had a 30 MHz bandwidth. The reproduced video information had a resolution of approximately 725 lines in both the horizontal and vertical directions and gray scale reproduction was limited to 5 out of 10 shades of gray.

The storage tube was similar in design to a cathode ray tube; however, the storage tube had an additional dielectric-coated grid closely adjacent and parallel to the target (viewing screen). The grid was the element that stored the video image and, for reproduction of the stored information, required constant scanning (electron bombardment) by the electron gun of the CRT. Due to the constant scanning, the stored image was subject to decay and had a usable viewing life of between 15 to 30 minutes.



STORAGE TUBE

Figure 21 HIGH RESOLUTION VIDEO FRAMEGRABBER

In addition to storing one frame of video information the electronics were designed to permit expansion of the stored image. Front panel horizontal and vertical position and expansion controls were incorporated into an electronic zoom capability which allowed for continually variable image enlargement up to a maximum of 36 to 1 in area.

VIDEO HARD COPY

A prime use of the high resolution video storage device is for the temporary storage of retrieved microfiche information. To provide for a means of making a permanent facsimile copy of the stored image, a video hard copy unit was used in conjunction with the high resolution framegrabber. Hard copy is obtained by systematically scanning the target of the storage device and reproducing the target information, by a scanning technique within the printer, on dry-silver paper. An 8½ by 11 inch copy is reproduced in approximately 18 seconds at a per unit cost of six cents. The dry reproduced copy can be handled much like conventional paper in that it could be written on with pen or pencil and pencil marks are erasable. Image retention, however, is reduced with continual exposure to light and the shelf life of the unexposed paper is approximately six months. The video printer is shown at the extreme right in Figure 26.

MICROFICHE STORAGE AND RETRIEVAL

A large amount of information that is processed on Air Force bases is available in the form of drawings, records, maps, etc. To be useful, much of this stored information must be retained in its original form. A microfiche retrieval system can make the retention of a vast amount of information manageable while retaining the capability of reproducing the original in the form of an image

display on a video monitor or a printed paper copy. A microfiche retrieval system that offered record protection on film, simplistic update of records, modular expandability, and a hard copy reproduction of fiche information was selected for experimental evaluation.

The microfiche storage and retrieval system as shown in Figure 22 consisted of a remote and local selection mechanism, a carousel microfiche holder, projection unit, viewing screen, and hard copy printer. The unit could be operated locally by entering microfiche address information on an array of front panel selection controls. Local operation was desirable to permit operator access and retrieval of the fiche in order to update and replace the files.

In the remote mode of operation the fiche selection control information generated at a work station keyboard was transmitted to the retrieval system wherein it initiated the selection cycle. Microfiche were selected from a carousel that contained a maximum of 750 slides. Slides consisted of a 7 mil thick film base material approximately 4 x 6 inches in overall size mounted on a metal hanger that was notched to represent a unique slide address. A slide could contain a maximum of 98 images each of which was positioned at the coordinates of a 7 x 14 array. When selected for viewing an image was magnified and displayed at 24 times its recorded size for a resultant viewing image of 8½ x 11 inches. An integrated electrostatic printing module was contained in the same chassis with the basic microfiche retriever mechanism. The module was capable of photo-projecting the slide image into the reproduction system which produced a dry paper copy with either a positive or negative image produced in approximately 13 seconds.

The complete system which stored approximately 75,000 micro-filmed pages of information per carousel can be expanded by modules up to a maximum of 9 carousels.

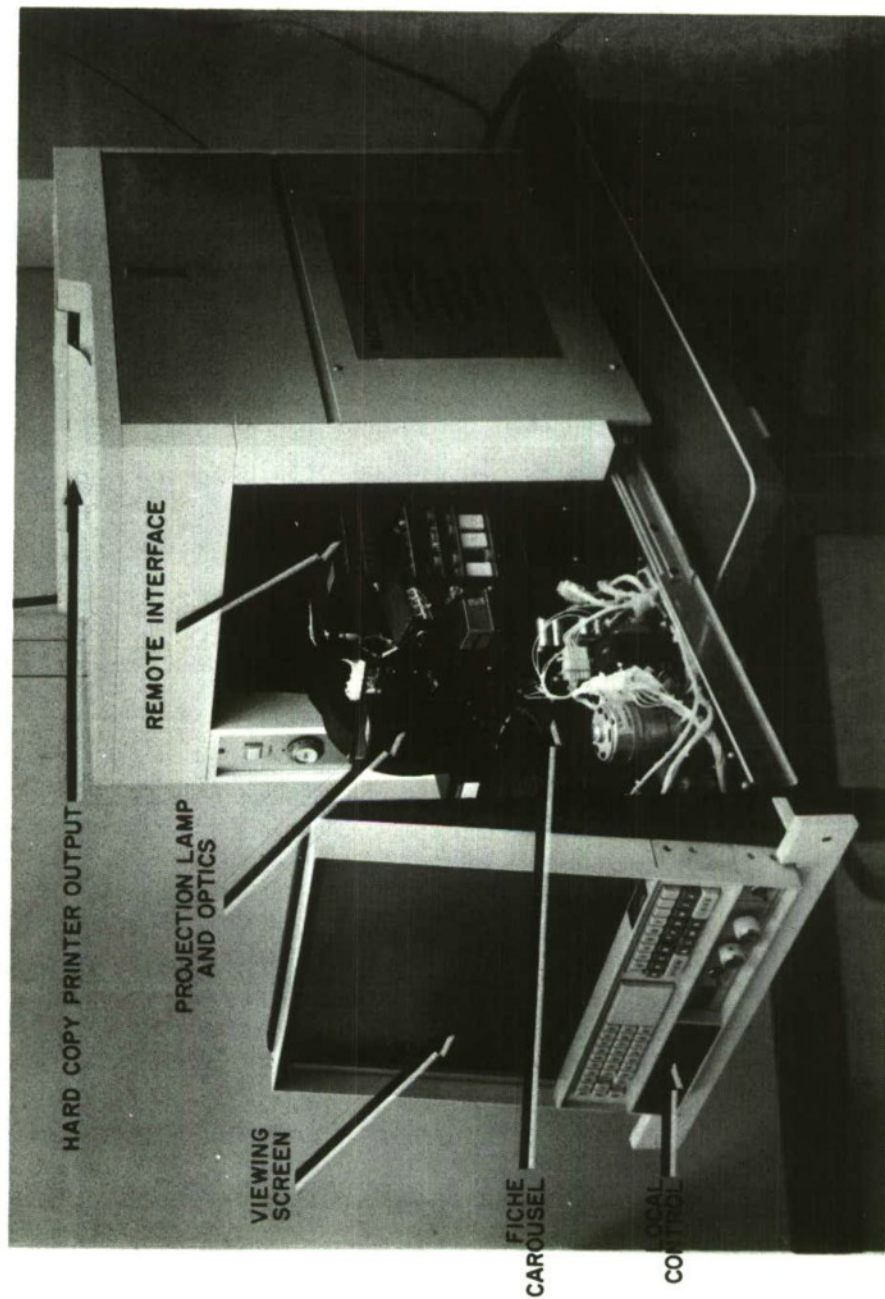


Figure 22 MICROFICHE STORAGE AND RETRIEVAL UNIT

SECTION VII

EVALUATION CONFIGURATIONS

In order to evaluate the performance of typical AFBITS work station equipment configurations the terminal equipments were connected in a switched hub configuration wherein a broadband switch served as the central switching point (Figure 8) to provide a flexible interconnect capability. Three basic categories of equipment configurations were evaluated each relating to the type of interconnect information transferred on the coaxial cable, i.e., digital data, video, and digital data/video. A total of nine equipment configurations were evaluated with consideration given to signaling and supervisory control problems, interface problems, and operational usage problems.

DIGITAL DATA CONFIGURATIONS

Digital data terminal configurations were evaluated as shown in Figure 23. These configurations are representative of the types of interfaces encountered in electrical to electrical, and electrical to mechanical digital data transfer.

Soft Copy to Soft Copy Information Transfer

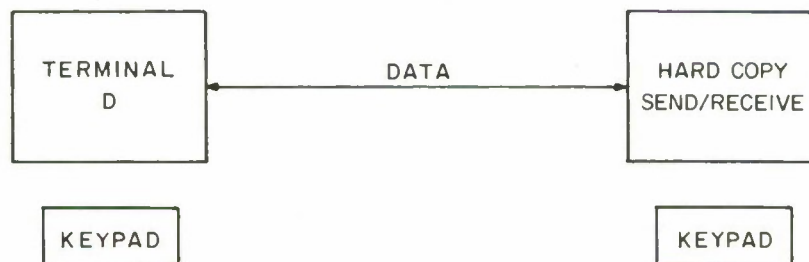
As shown in Figure 23A, two stand-alone soft copy terminals, Terminal D and Terminal K, were connected through the broadband switch and operated together. Various problems were encountered in this evaluation as follows:

Plug Compatibility

Plug to plug compatibility was the first problem encountered. Manufacturers of data terminals normally supply either a parallel or serial input/output interface with a variety of data formats and voltage input/output levels. The data terminal devices utilized were RS-232 compatible (Section VIII) which meant that the voltage



23A SOFT COPY TO SOFT COPY



23B SOFT COPY TO HARD COPY

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Figure 23 DATA CONFIGURATIONS

levels, transmission format, and handshaking requirements were designed to the same standards. Although data transmission and reception are serialized over a single transmit and a single receive wire, there were still handshaking requirements to be resolved at the interface. For an AFBITS configuration, a single serial line, transmit or receive, is desired. Consequently, for an RS-232 type of interface, provision must be made to interconnect the proper handshake lines at the terminal interface in such manner that the requirements of the RS-232 standard are satisfied. Also, the number of data bits per word, parity bit (odd, even, none), and number of stop bits must be specified in order to have a satisfactory interface. For the experimental evaluation, seven data bits, no parity bit, and one stop bit were used.

Transmission Rate

Having determined the above requirements at the equipment interface it was also necessary to select a data transmission rate for each device. Most peripheral equipment designed for serial asynchronous and synchronous data transmission can operate at either a fixed preset baud rate or a switch selectable baud rate within the range of 110, 150, 300, 600, 1200, 1800, 2400, 4800, or 9600 baud. Normally it is desirable to operate at the highest transmission rate consistent with the interface hardware capability in order to minimize the update time for a complete viewing screen of data. For instance, at a 2400 baud transmission rate, and the assumption of 10 bits per character (7 data, 1 parity, 1 start, 1 stop), and 2000 characters per screen (25 rows of 80 characters per line), the update cycle time for the presentation of new data is approximately 8 seconds. The soft copy to soft copy terminal information transfer rate for the evaluation was at 1200 baud due to a hardware I/O limitation of one of the terminals.

Code Compatibility

Once the line interface and transmission rate requirements are satisfied a character code must be specified for the terminal equipments to communicate with each other. The ASCII character set (Section VIII) was selected as the coding standard in order to properly interpret the character and control codes passed across the interface. Care must be taken to ensure that each terminal contains a character generator capable of handling the character repertoire of the other. A typical mismatch would be a upper/lower case character set terminal communicating with a upper case only character set terminal. An equally important factor to be resolved is the equipment interpretation of the control character set. Each terminal must decode and operate on the control set in a similar manner. An example of incompatible control set command decoding would be the Carriage Return function which could mean simply return the cursor to the leftmost position on the line, or else return the cursor to the leftmost position on the line and also line feed down to the next row.

Format Compatibility

Terminals as manufactured provide a variety of display format capabilities. Typical display formats range from 32 to 80 characters per row and 16 to 27 rows of characters in various combinations. In a system of mixed terminal equipment, consideration must be given to the format capability of each display, otherwise, data may fold-over between lines at undesirable locations. Also there is danger of losing data, especially if consideration is not given to the internal (displayable and non-displayable) buffer storage capacity of the terminals. Some terminals have an extended memory which permits storage of that data which exceeds the display capability but with all data being accessible and viewable through scrolling

techniques. Terminals with the extended memory capability usually allow the entire contents of memory to be transmitted.

On-Line/Off-Line Operation

Since it is often desirable to compose text information on a terminal prior to transmission, many terminals provide an on-line/off-line capability. To minimize the time utilization of transmission facilities text entry, formatting, and correction are frequently accomplished off-line after which transmission of the full contents of memory is made on-line at the highest transmission rate available. For such circumstances in an AFBITS installation, where self-contained terminals are operating in tree type configurations, provision must be made in the control and supervisory network to inhibit off-line terminal reception of input which could overwrite any message preparation that was in process in the terminal.

Phosphors

Two different types of phosphor were employed in the visual display terminals evaluated. The majority of displays used the conventional commercial television standard white phosphor (P4). Digital data was displayed as white characters on a gray background with this phosphor and was deemed acceptable by most users. This mode of display is also compatible for the display of normal television video information.

A negative image character set in which the digital data appeared as dark characters on a white background was evaluated and was found to be less desirable under normal room lighting conditions since the contrast ratio appeared poor. Televised video information to such a display would appear as a negative image. However, this was not considered a disadvantage since an additional electrical signal inverting stage could easily be incorporated into such a display terminal.

The second type of phosphor used on one terminal evaluated was P31 phosphor which displayed information as green characters on a light background. In general, user acceptance for text information display on a green phosphor was more favorable than that for the same information displayed on white phosphor, since the information displayed appeared to be more readable and less fatiguing to the eyes. However, the P31 phosphor is unsuitable for display of television video information because of its color (green) and its longer persistency which appears to smear motion in video pictures.

Keyboard Entry

The alphanumeric entry keys on the display terminal keyboards were configured in the same format as those on a standard typewriter. The only key to cause problems with data entry was the space bar. A conventional typewriter space bar activation moves the carriage one increment while jumping over any character that might be present on the paper at the location where the space bar is activated. In soft copy terminals, however, the space bar, when activated, normally generates a space character on the display at the location indicated by the cursor and then increments the cursor to the next character position. Unlike the standard typewriter, activation of the visual display terminal space bar will replace any alphanumeric character, located at the cursor position, with a space character while erasing the character present at that location. This feature is particularly undesirable especially when backspacing to correct a character within a word. A more expedient method would be the use of a split space bar in which activation of one portion would generate a space character and then increment the cursor, while activation of the second portion would increment the cursor only without any change to the displayed information.

Soft Copy to Hard Copy Information Transfer

The generation of a hard copy output of material prepared and processed as soft copy in an AFBITS installation requires the inter-connection of soft copy terminals with printer devices. A hard copy send/receive terminal (an electrified typewriter with input/output capability) connected to a soft copy video display terminal or a text editing microprocessor is shown in Figure 23B. The type of connectivity evaluated is representative of an electrical terminal to mechanical terminal class of interface. The problems identified in this evaluation in addition to those previously discussed in the Soft Copy to Soft Copy considerations were as follows:

Plug Compatibility

The majority of I/O typewriters have, at their interface, parallel control and data lines. A parallel input to serial output, and a serial input to parallel output line converter was designed to interface the parallel input/output classes of peripherals used in the evaluation, to the AFBITS serial coaxial cable data ports. The unit consisted of a baud rate clock which could be selected to match the serial data transmission rate, a RS-232 digital receiver/transmitter unit which converted serial data to parallel data, and also parallel data to serial data, a 9 bit by 40 word first-in, first-out buffer, and the necessary control logic for matching the handshaking requirements of the peripheral.

Transmission Rate

I/O typewriters and printers being electro-mechanical devices are inherently slower than soft copy electronic terminals. The gating factor on data transfer speed is not the print rate alone but is derived from the combination of the print rate, carriage return time, line feed time, and upper/lower case shift time. The maximum rated print speed for the hard copy devices used was

approximately 15 characters per second. After considering the preceding gating factors, however, the true average print rate was determined to be approximately 12 characters per second for general correspondence. To insure a reliable interface in which the average input data rate would not exceed the average printing rate, the interface transmission rate was limited to 110 baud (11 characters per second). At this baud rate, a 2000 character information transfer required approximately 3 minutes.

Data Loss

When the soft copy to hard copy information transfer configuration was operational two types of data loss were observed. One type of data loss was related to mechanical factors and the other to electrical factors.

Mechanical Data Loss. Data was observed to be lost even though the input data rate of 11 characters per second was less than the average print rate. Investigation disclosed that carriage return time can be significant, approaching upwards of 900 milliseconds which is approximately the time required to transmit 10 characters of information. To alleviate the problem, an 11 character first-in, first-out buffer register was designed and installed at the interface. The buffer stored information during the carriage return and other abnormal cycles and outputted the information at the maximum rate of the I/O typewriter which, for characters of the same case, approached burst rates of 15 characters per second. This evaluation revealed that for correspondence typing an 11 character buffer was minimal and a 16 character buffer would be more desirable. However, to accommodate a variety of users, especially statistical typists who frequently shift case, a complete one-line buffer capability would be recommended.

Electrical Data Loss. Some data entry information generated from the hard copy keyboard appeared to be lost during the information transfer cycle. The I/O typewriter keyboard, being mechanical in nature and linked internally to the typewriter mechanism was suspect. However, investigation with solid state keyboards revealed that efficient typists can generate data at rates approaching 20 characters per second, especially on words that have "ing" at their end. The problem can be alleviated by selection of a higher baud transmission rate for the hard copy output interface, e.g., 300 baud which is approximately 30 characters per second. However, care must be taken to insure that both devices in the connectivity can operate at different transmit and receive rates. An alternate solution is to specify a rollover buffering capability in the keyboard to store and smooth out the transmission rate of the burst characters.

Code Compatibility

In addition to specifying compatibility to the ASCII character and control code, there is another inherent problem that frequently arises at a hard copy to soft copy terminal interface. In soft copy terminals, carriage return interpretation depends upon whether or not the device is teletype compatible. In teletype compatible devices, a carriage return must be followed by line feed in order to return the cursor and increment it one line. In non-teletype devices (both soft copy and typewriter) a carriage return command will return the cursor (carriage) to the leftmost position and increment the line one row. Consequently, an interconnectivity between a teletype compatible device and an I/O typewriter will, in general, produce a carriage return and a double line feed on the transfer of information to hard copy, and only a cursor return without line feed when transfer is made from I/O typewriter keyboard to soft copy terminal. The equipment evaluated had optional

selection switches that allowed operation in either teletype or non-teletype mode.

On-Line/Off-Line Operation

Most I/O typewriters, including the type evaluated, have no character storage capability. In an off-line mode the hard copy terminal responds as a normal typewriter. On-line, however, any data input initiates a print cycle, and any keyboard keystem depression generates and outputs a data character. Consequently, the throughput with respect to transmission channel capability is very low. In a broadband transmission system where there is significant bandwidth, transmission efficiency is not always of prime importance. However, for soft copy to hard copy terminal interconnections, the trade-off between providing hard copy terminal buffer storage for composition prior to complete message transfer, and the effective down time of the soft copy terminal while waiting for a reply should be considered.

Miscellaneous Problems

In the operation of the hard copy to soft copy configuration a number of lesser problems were also observed.

Paper was inserted a sheet at a time into the terminal when it was used for high quality correspondence generation. Although automatic form feeders are available they may not prove to be satisfactory because of paper registration problems and other general paper feed problems caused by paper type, weight, and moisture content.

Many hard copy terminals do not have provision for signaling an out of paper, or an out of ribbon condition which are important options when the terminal is running unattended. Another important factor to consider, especially, for multiple hard copy terminal installations, is the amount of acoustic noise generated from the operation of such electro-mechanical terminals.

VIDEO CONFIGURATIONS

The three 'video only' configurations shown in Figure 24 were used to evaluate video storage in the form of continuous video recording and retrieval, single frame video storage and retrieval, and remotely accessed and controlled video surveillance equipment.

Continuous Frame Video

A 525 line video television camera, a video cassette tape recorder (VTR), and a 525 line black and white video monitor were configured as shown in Figure 24A for evaluation of the control and operational problems involved in the storage, retrieval, and display of dynamic video information. The VTR, which is considered to be common user equipment, was operated both locally in conjunction with the video source or display, and remotely as would be the case for data base library applications.

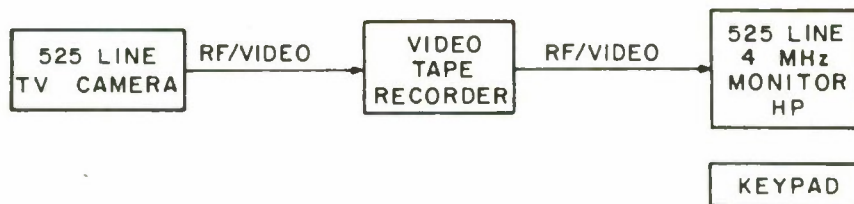
Local Operation

Once connectivity was established and the type of signal transfer (RF carrier or baseband video) was selected, local operation posed no apparent problems because all of the equipments for local operation had the capability to send and/or receive both baseband video and RF information. The equipment involved was all conventional 525 line, 6 MHz television equipment with composite sync derived from the video source.

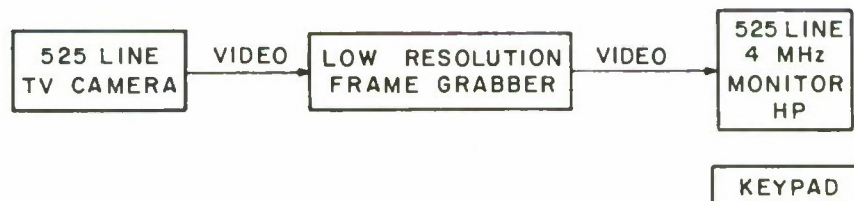
Mechanical operation of the VTR was under local operator control and, as such, program selection, recording, and playback was accomplished by visual observation and/or verbal communications.

Remote Operation

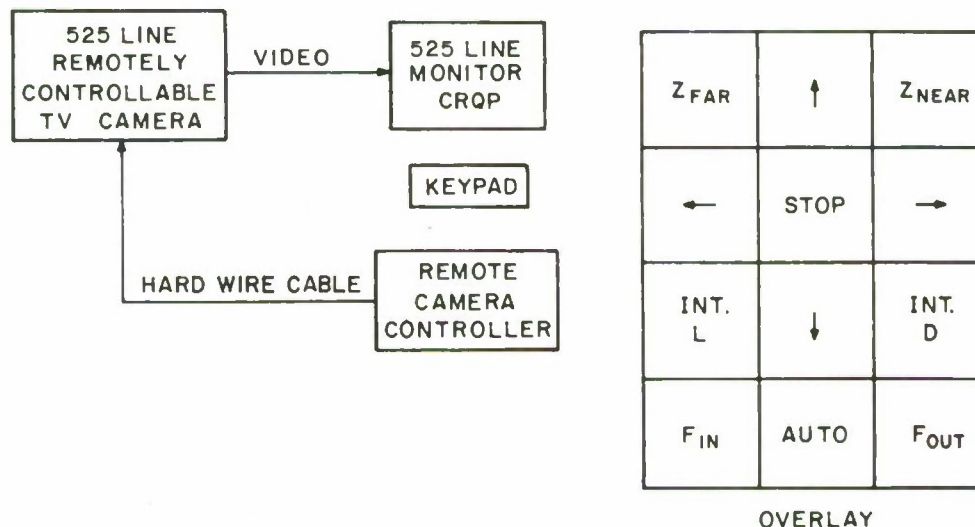
In remote operation, where the VTR resides at a distance from the source and viewing equipment, an additional channel of communication was required in order to forward commands and requests from



24A. CONTINUOUS FRAME VIDEO



24B. SINGLE FRAME VIDEO



24C REMOTE VIDEO

Figure 24 VIDEO CONFIGURATIONS

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the source/viewer to the VTR operator. The VTR was not a remotely controlled device and required an operator to select, insert, and remove cassette tapes as well as to start, stop, and adjust signal levels. Remote recording without direct visual contact with the source was considered to be awkward by the users, whereas, remote viewing with audio communication for setup with the VTR operator was acceptable.

Single Frame Video

Video information is normally transmitted at a 30 frame per second rate, i.e., one complete frame (picture) of information in 1/30 of a second, and is generally thought of as being dynamic in nature. However, there are many applications in which fixed video information is desired. Typically, a security check point could require a fixed video picture for comparison with an individual wishing to gain access to an area.

Large amounts of unrelated still picture video information can be accessed by subscribers and displayed on their video monitors if a means of intermediate video storage and display refresh memory is used. Such devices (framegrabbers) were discussed in Section VI and are part of the common user equipment. A low resolution framegrabber (LRFG) was interfaced with a video source (TV camera, video tape recorder, or other devices), and a monitor (Figure 24B) to evaluate the transmission and control problems associated with such a configuration of equipments.

All equipment was of the standard low resolution 525 line, 60 Hz, 4 MHz bandwidth variety. Video from the source could be modulated and transmitted as standard TV channel frequencies or as baseband video, while video from the output of the LRFG was baseband video. As previously mentioned in Section VI, the resolution of the LRFG is limited and, as a result, the configuration was suitable only

for storage of standard black and white television frames. One evaluation that was conducted involved two adjacent similar monitors one of which received still-picture video direct from the source while the other received an identical frame of information from the LRFG. The display quality of the two monitors was compared first with alphanumeric information only and then with graphic information only and, in both instances, were judged to be approximately equal to the eye.

Frame capturing was accomplished under the local control of a momentary push button switch. No attempt was made however to design a remote controller to initiate capture of either a single random frame or to count and capture specific frames. A controller to assign numbers to the frames at the source and a controller to decode and initiate capture commands at the LRFG would be required if the system was designed for use with still picture transmission techniques.

Remote Controlled Video Source

A remote controlled surveillance capability was also included in the test configuration to evaluate the problems associated with assignable master control, control priority, and surveillance information distribution. As previously described, the remotely controlled roof-top mounted camera could be positioned both in elevation and azimuth, and the iris, focus, and zoom ratio could also be remotely varied. The 525 line TV camera had built-in compensation to self-adjust for the normal changes in illumination that occurred during daylight hours but was not designed to be a low-light level surveillance device.

A design for remote keyboard access to the video camera controller was completed, but was not implemented. Instead, the controller was physically positioned at the work station which

requested access to the system. However, from the system design that was conducted, and from the operational evaluation that was made, the only apparent control problem is one of assigning priorities as to what work station may interrupt an on-going surveillance connectivity of another and assume control of the system. Since a Network Central Control Processor is the gating point through which all connectivity control requests must pass, a priority sub-routine within the net control processor would handle such problems.

The surveillance camera system, being part of the common user equipment, could be accessed by any authorized work station. Because of this flexibility, security check points, which previously had been immobile because of equipment constraints, become assignable. Also, connectivity can be made to other compatible common equipment (framegrabbers, video tape recorders, video printers, etc.) for expanded system performance.

Design of a remote access interface into a camera controller would be such that after establishing work station connectivity, control information to the camera could be entered from the work station keyboard. An overlay (shown in Figure 24C) could be superimposed over a 3 by 4 array of keys for easy identification of control functions. Typical keyboard control would include ZOOM FAR-NEAR, INTENSITY LIGHT-DARK, FOCUS IN-OUT, PAN, TILT, AUTO-SCAN, and STOP FUNCTION. In an auto-scan mode the camera would be positioned and sweep limits and rate of sweep preset; depression of the AUTO-SCAN would initiate action that would continue until depression of the STOP FUNCTION key or interruption by a high priority user.

COMBINATIONAL DIGITAL/VIDEO CONFIGURATIONS

Combined digital/video connectivities for data entry from a keyboard resulting in a video display were evaluated using two basic

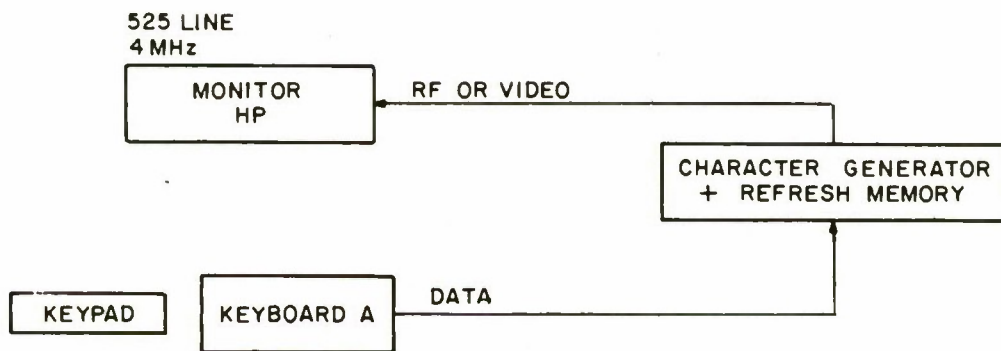
equipment configurations. In the first configuration data entry resulted in the generation of a soft copy alphanumeric character display on a TV monitor. In the second configuration data entry resulted in a graphic display on a TV monitor from a microfiche retrieval system.

Alphanumeric Generation

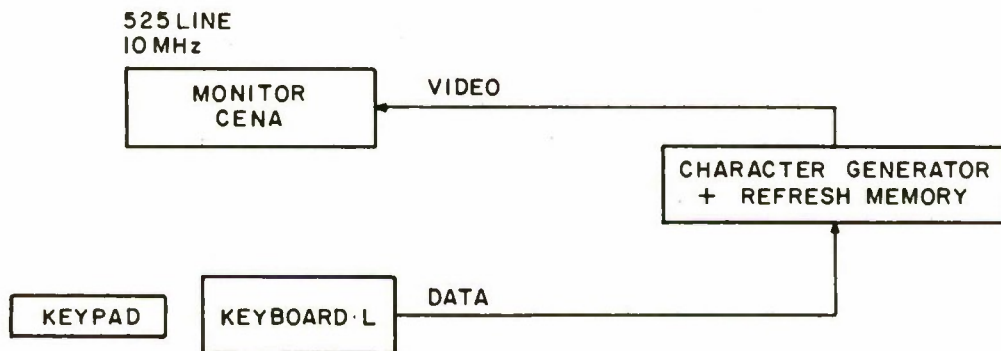
The amount of legible alphanumeric data that can be displayed on a television monitor is limited by the video bandwidth and the number of active scan lines of the monitor/character generator/refresh subsystem. A rule of thumb derived from the laboratory evaluation of various bandwidth monitors when combined with different character generators was that 15 KHz of monitor bandwidth is required for each legible horizontal displayable dot. For example, a conventional television monitor with 4 MHz bandwidth can legibly reproduce 266 dots which represents, for a 5 by 7 character dot matrix (5 dots plus 1 intercharacter space dot wide, by 7 dots high), approximately 44 displayable characters per line. To assess legibility limitations due to bandwidth, two equipment evaluations were made. One evaluation was with conventional (6 MHz transmission channel, 4 MHz video information) monitors - typical of those used with computer interactive displays, while the other was with moderate bandwidth (15 MHz transmission channel, 10 MHz video information) monitors - typical of what could be used for secretarial correspondence displays.

Conventional 6 MHz Channel Work Station

As depicted in Figure 25A, a keyboard, character generator/refresh memory, and a 525 line standard 4 MHz bandwidth monitor were connected together into a work station configuration. Data entered at the keyboard was transmitted as digital information to the character generator/refresh memory, from which alphanumeric



25A. 6 MHz WORK STATION



25B. 15 MHz WORK STATION

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Figure 25 DATA/VIDEO CONFIGURATIONS

character information in the form of dots, was transmitted to the display monitor either as RF or baseband video. The character set displayed from the baseband video transmission was of higher quality than that of the RF transmission and was a result of the broad bandwidth of the baseband transmission. However, both were satisfactory within the limits of the evaluation.

Defocusing and unusable edge area of the display must be considered when prescribing the writing area on the display. Defocusing of the electron beam occurs as the beam is moved off the center axis of the tube. Although electronic correction circuitry is incorporated into most monitors, the spot growth can cause legibility problems at the corners of the viewing screen. Additionally, the CRT is not square at the corners and in most monitors the raster coverage would exceed the visible display area with a possible loss of the display character format.

With the character generator used, the number of displayable rows was limited to 16 and was less than desirable for several applications. The typical inexpensive character generator/display system commonly associated with the majority of terminal systems is television (raster scan) oriented. As such, the number of displayable rows is dependent upon the size of the character dot matrix field and the number of scan lines used. The majority of monitors are 525 line television compatible with 2:1 interlace for an approximate total of 480 active scan lines upon which character display information may be presented.

For display of upper case characters only, a 5 by 7 dot matrix character font could be used. Allowing for 3 interline spacing dots per row (a format in which a cursor could be placed on the middle line) a total of 10 scan lines per row are required. Thus, for the situation described, a maximum of 48 lines of 32 characters

per line could be displayed. The capacity of the visual display monitor for correspondence generation should be 51 rows of 80 characters each.

For display of both an upper and lower case character set a larger dot matrix character font must be used. This would be required for legible reproduction of the lower case character set which requires descenders for such letters as g, y, etc. A typical character font could be contained within a 7 by 11 dot field. Allowing for 3 interline spacing dots, as in the previous example, a total of 14 scan-lines per row are required which, for a 525 line system, permits a maximum of only 34 rows of character information to be legibly displayed.

Moderate 15 MHz Channel Work Station

The display limitations of a work station configuration employing a 4 MHz bandwidth monitor would restrict its usage to applications which required a low number of displayable characters per line and would therefore generally be unsuitable for correspondence preparation. The work station configuration shown in Figure 25B includes a moderate bandwidth (10 MHz video bandwidth, 15 MHz transmission channel) 525 line monitor which, using the rule of thumb of 15 KHz bandwidth per dot, allows for the legible reproduction of 666 dots per line. Since correspondence preparation requires both upper and lower case characters, a character font contained within a 7 by 11 dot field would be desirable. Allowing for 2 intercharacter space dots for a total of 9 dots per character width, approximately 74 characters per row can be legibly displayed. The equivalent of the evaluation configuration shown in Figure 25B displayed 80 characters per row with excellent legibility.

In the AFBITS evaluation equipment implementation, a channel bandwidth of 15 MHz was selected for use with any service package

configuration that required a video correspondence channel. Such a channel will accommodate the wide bandwidth 525 line monitors currently in production for video terminals. The equipment manufacturers appear to have standardized bandwidth for video display terminal monitors at 7.5, 10, and 15 MHz.

MICROFICHE RETRIEVAL

Vast amounts of information such as manuals, records and other routine forms must be stored and maintained on Air Force bases for access by a variety of users. A microfiche retrieval system could be used as a means of reducing the physical volume of the stored data. However, such reduction and storage of information would only replace volumes of paper and files with large amounts of microfilm frames and would not lessen the problem of retrieving, distributing, and reading such information.

To evaluate the problems involved in access, control, and the legible reproduction of information stored in a microfiche system two evaluation configurations were made. In the first configuration a direct video scan interface was used to evaluate requirements of pickup and reproduction devices and to allow investigation of the resultant deficiencies. In the second configuration an indirect video interface through a framegrabber was used to evaluate system configuration and operational control problems.

The equipments used for the microfiche retrieval system evaluation are pictured in Figure 26. Shown from left to right are the high resolution video camera, microfiche retrieval unit, local monitor and TV camera control unit, high resolution video framegrabber, and video hard copy printer.



Figure 26 MICROFICHE RETRIEVAL SYSTEM

Direct Retrieval System

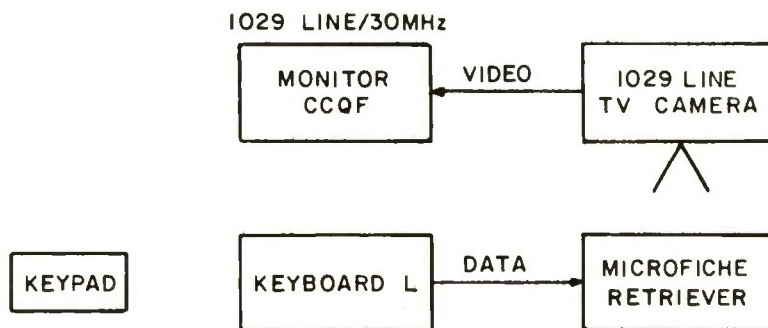
A work station consisting of access keypad, data entry keyboard, and a 1029 line high resolution TV monitor was interfaced with a microfiche retrieval device consisting of a remotely controlled retriever and a 1029 line high resolution 30 MHz bandwidth video camera as depicted in Figure 27A. All information transfers were at baseband frequencies.

Fiche Selection

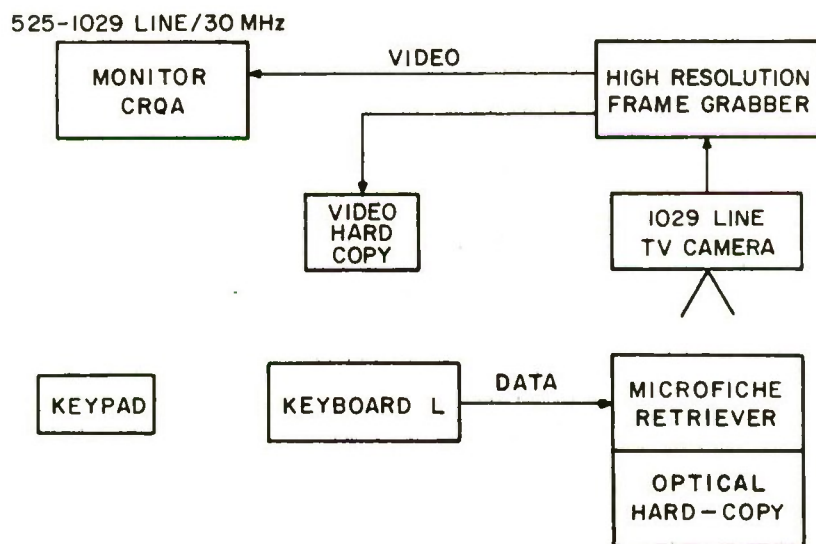
For the evaluation two pointers were provided for referencing the desired fiche: the first was a directory that tabulated fiche subject vs. storage location, while the second was an index of subject material stored within the system and was available on fiche number zero.

An eight digit fiche address selection code was required to access any one of the 75,000 stored images. The code was entered from a subscriber work station keyboard and was judged to be awkward. The format required three character entries corresponding to the retrieval system number followed by an additional three character entry relating to microfiche slide number (0 to 749) and finally a two digit X-Y position number. Operators experienced difficulty paging through multiple fiche sequences since there was no direct number correspondence and no compatibility between slide number requests and position requests. For example, to select fiche number 12 the characters "@AB" had to be entered from the keyboard, whereas the selection of image 12 on the Y axis required the entry of "C". An improved sequencing method would have to be established for a viable operating system.

Any microfiche image in the operational system could be random accessed and displayed within a four second period.



27A. DIRECT VIEW MICROFICHE RETRIEVAL SYSTEM



27B. OPERATIONAL MICROFICHE RETRIEVAL SYSTEM

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Figure 27 MICROFICHE RETRIEVAL CONFIGURATIONS

Information Conversion and Remote Display

The equipment used in the evaluation displayed selected microfiche images on a front panel ground glass viewing screen that was an integral part of the microfiche retrieval mechanism. An internal 150 watt projection lamp with condensing lenses supplied illumination to the selected slide whose image was magnified and displayed at 24 times film size. The resultant display suffered from insufficient and non-uniform contrast and brightness over the viewing surface. A visible 'hot spot' of light resulting from the projection system, and excessive light impinging on the viewing area, were the prime causes of the viewing inadequacies.

In the operational configuration, fiche selection information from the work station keyboard caused a resultant image display on the retrieval unit which was scan-converted by the video camera and transmitted to the subscriber's work station monitor for display. The conversion from the projected image to electrical information was accomplished by focusing a high resolution video camera on the microfiche viewing screen. The camera, a 1029 scan line, 60 Hz field rate, 2:1 interlace, 30 MHz unit, with its associated remote high resolution monitor had a combined resolution in excess of 750 horizontal and vertical lines across the scanning area. The non-uniform intensity and contrast problems were immediately evidenced on the resultant video display. For further evaluation within the experimental configuration a modification should be made to the light distribution system to redistribute the light in a more uniform manner. However, such a modification will not be satisfactory for operational information retrieval systems. As a result of this problem, an industrial survey was conducted regarding the practicality of an improved light distribution and/or an improved image conversion system. The survey uncovered several manufacturers who resolved the problem by installation of a flying-spot scanner

adjacent to the microfiche slide. The scanner replaces the illumination, projection, magnification, and viewing screen in the microfiche retrieval system, and the video camera that converted the information into electrical signals. With this approach the flying-spot scanner may be thought of as video camera that directly scans the microfiche slide. Further industry investigation resulted in the discovery of a manufacturer who has interfaced a flying-spot scanner into the same basic microfiche retrieval mechanism that was used in the AFBITS experimental equipment configuration.

Image Reproduction

From several previous studies that have been conducted (Reference 1) on the legibility of displayed symbols reproduced in a television environment the rule of thumb for image reproduction that has been derived is that legible television reproduction of typewritten characters requires a minimum of 10 active scan lines per symbol height. Based on this rule and the assumption that the video scanning device will cover a vertical dimension of 11 inches for a 1029 scan line system with 945 active scan lines, then the minimum character height (with respect to the 11 inch dimension) should not be less than 0.116 inch. From the standard point size of one point equal to 0.01383 inches, the minimum point size on the page therefore should not be less than 8 point which corresponds to Brevier type. Typical type and point sizes are: Small Pica, 11 points - Pica, 12 points - and English, 14 points. Consequently these character fonts when typed on an 11 inch page will have more than the required minimum of 10 scan lines per symbol height.

A standard 8½ by 11 inch page printed with Pica type was directly scanned by the video camera and reproduced on a TV monitor. The resulting image was judged to be satisfactory over the viewing area. However, the same information when reproduced on a microfiche slide and viewed through the microfiche video retrieval system

was not legible across the viewing area of the TV monitor due to the illumination non-uniformities that were previously discussed.

A major fault with the use of conventional television equipment for the display of standard printed material is the orientation of the information area. The normal TV equipment aspect ratio is 4:3 (horizontal:vertical) whereas that of a printed page is approximately 3:4 (horizontal:vertical). As a result of this format mismatch there is a loss of information capacity because, without any adjustments to the video equipment, the retrieval material is overscanned. If the monitor and camera could both be turned on their sides a more perfect match of aspect ratios would result. This was demonstrated with the evaluation configuration with a resultant improvement in the transmitted picture. For a versatile work station capability, however, the monitor must reproduce both conventional video (4:3 ratio) and microfiche retrieval video (3:4 ratio). A satisfactory solution would be the use of a self adapting monitor with two preset aspect ratio's and a round cathode ray tube. An evaluation of this technique was performed using the type CCQA monitor previously described. A 4:3 ratio was set for all 525 line applications and a 3:4 ratio was set for microfiche retrieval applications. In the microfiche viewing application the resultant monitor image was less than full size due to the 14 inch CRT being rectangular. The overall evaluation proved quite satisfactory however and indicated that a properly designed scanner and monitor would yield legible information.

Miscellaneous Problems

Several minor problems were also noted while using the microfiche retrieval mechanism. When an improper X-Y position address is entered (one that exceeds the prescribed X-Y coordinates) the mechanical portion of the selecting device hangs in an active

select position, i.e., the motors, stepper solenoids, etc. lock up in a constant motion cycle. As presently designed, the only reset technique available was to power down/power up the retrieval system.

Occasionally a slide would misregister slightly, a problem that would be magnified if slides generated from many sources were included in the same data base. The retrieval system as designed makes no provision for incremental X-Y position control to recenter skewed images.

In a somewhat similar manner, no provision was made for remote control of the focus mechanism. This feature would be especially important in situations where a mixture of different thickness film material was employed.

Finally the retrieval mechanism occasionally jammed and the cause was attributed to static charge build-up on the negative film material which, because of its attraction to other material would result in skewing the film holder with consequent malfunction in the selection mechanism.

Indirect Retrieval System

The indirect microfiche retrieval configuration evaluated consisted of a work station keyboard for fiche address selection, the microfiche storage and retrieval device, a hard copy optical image printer, a high resolution video camera, a high resolution framegrabber, a video hard copy printer, and a work station high resolution monitor. The evaluation configuration is pictured in Figure 26 and shown in Figure 27B. A retrieval cycle consisted of keyboard fiche address selection, mechanical slide retrieval and projection, information scan-conversion with the video camera, framegrabber storage, and monitor reproduction with the video from the framegrabber unit. This cycle of operation would be necessary

in an operational system to insure that no one subscriber would tie up the microfiche storage and retrieval system for longer than a four second period while viewing selected information. In a typical operational system there would be several framegrabber units, one of which would be associated with each subscriber requesting the microfiche retrieval service package. This would allow multiple users access to common microfiche data bank without undue waiting periods.

The high resolution framegrabber employed in the evaluation configuration was found not to be of suitable quality consistent with the other operational equipment. The overall resolution was inferior and resulted in a degraded reproduction of the stored image. Subsequent investigation of a new generation of framegrabbers revealed that high quality video storage devices that would approach the requirements of an operational system are now available.

Printers

Two types of hard copy printers were employed in the evaluation configuration. The first unit received its information electronically from the stored image in a framegrabber unit and transformed the information using a raster scan technique to dry silver paper. The second unit received its information by optical means directly from the microfiche slide and reproduced the image on paper using wet-copy techniques.

Video Printer

A video printer was used in conjunction with a high resolution framegrabber to reproduce a hard copy image of a selected microfiche frame. The reproduced image was observed to suffer from resolution degradation. Investigation revealed that the information loss was apparently caused by the output interface electronics of the framegrabber equipment. A hard copy output of a standard

test pattern processed by the system equipments is shown in Figure 28. The same model printer was observed interconnected with devices of other manufacturers and, in such configurations, produced acceptable printed output. Based on the results of the evaluation it should be possible to adequately specify the requirements of a framegrabber/video printer combination that would satisfactorily meet the needs of an operational microfiche retrieval system.

Hard Copy Printer

The second type of hard copy output was obtained directly from an optical projection electrostatic printing module that was incorporated into the same chassis that contained the microfiche storage and retrieval mechanism. The quality of the reproduced image was comparable to that obtained from a "Dennison" type copier and was judged to be satisfactory for most operational applications.

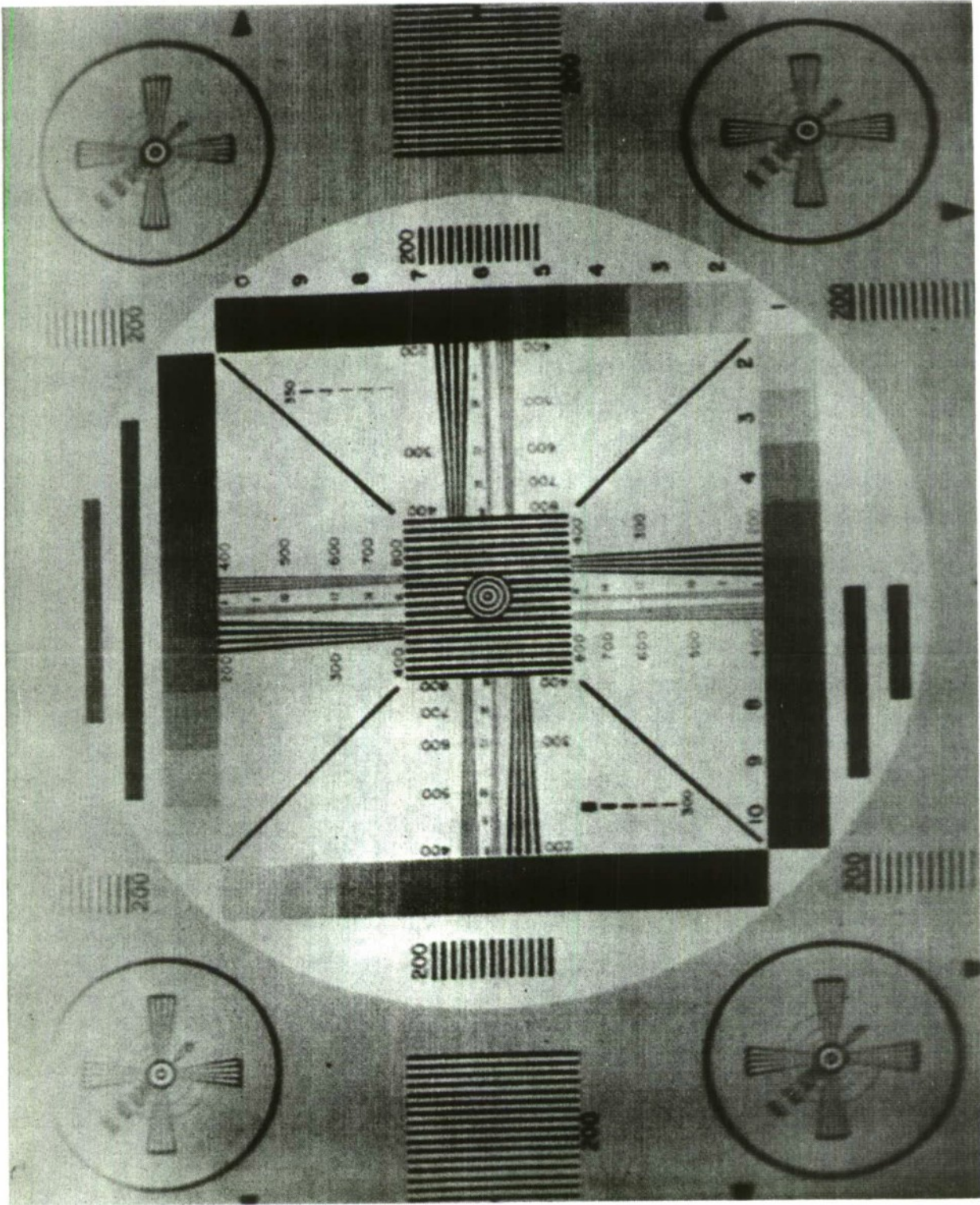


Figure 28 VIDEO HARD COPY PRINTER SAMPLE

SECTION VIII

STANDARDS

The AFBITS concept anticipates the use of off-the-shelf commercially available equipment whenever possible in developing many aspects of the system capability. In light of this fact, a number of standards which deal with data code structure, data transmission, equipment interfaces, etc., were adopted in implementing the evaluation configuration. The purpose of the standards is to act as a guide to eliminate incompatibility between equipments so as to facilitate operational interchangeability. Standards were initially developed to achieve this goal and though not mandatory they are generally adopted by industry as a whole. Standards applying to an AFBITS facility are published by two agencies:

a) The USA Standard, originally issued by the United States of American Standards Institute, became the American National Standard, now published by the American National Standards Institute, Inc. after a name change was effected in October 1969. The standards represent general agreement among maker, seller, and user groups as to the best current practice with regard to some specific problem.

b) The EIA Standards, published by the Electronic Industries Association. These engineering standards were designed to help eliminate misunderstandings between manufacturer and purchasers of electronic equipment, to help facilitate interchangeability and improvement of products, and to assist the purchaser in selecting the proper product for a particular need.

The following is a list of the standards applicable to AFBITS.

USAS X 3.4 - 1968

USA Standard Code for Information
Interchange (ASCII)

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|--------------------|---|
| USAS X 3.15 - 1966 | USA Standard for Bit Sequencing of the USA Standard Code for Information Interchange in Serial- by-Bit Data Transmission |
| USAS X 3.16 - 1966 | USA Standard for Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the USA Standard Code for Information Interchange |
| ANSI X 4.14 - 1971 | American National Standard for Alphanumeric Keyboard Arrangements Accommodating the Character Sets of ASCII and ASCSO CR |
| EIA RS - 330 | Electrical Performance Standards for Closed Circuit Television Camera 525/60 Interlaced 2:1 |
| EIA RS - 343-A | Electrical Performance Standards for High Resolution Monochrome Closed Circuit Television Camera |
| EIA RS - 232-C | Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange |

REFERENCE

1. G. L. Bell, Studies of Display Symbol Legibility. Part XVI:
The Legibility of Teletypewriter Symbols on Television,
ESD-TR-67-104, 10 March 1967.